modern castings

AFS FEBRUARY 1959

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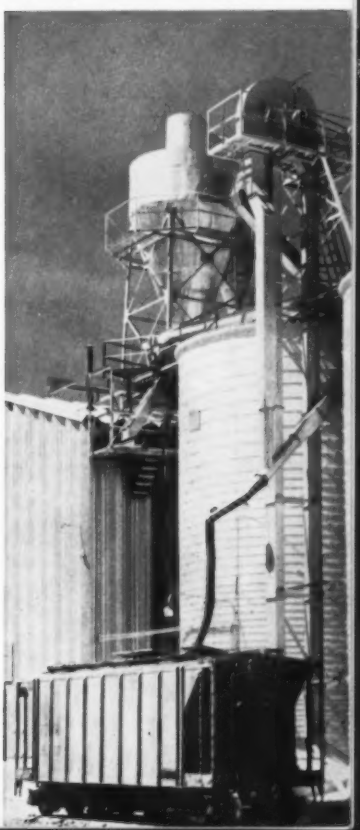
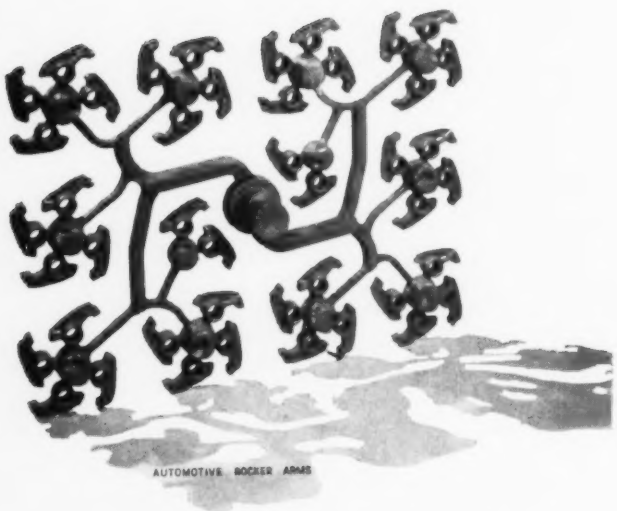
Producing bentonite, vital foundry material . . p 33





Central Foundry Division program aids customers in improving designs . . p 41

new technical manual for foundrymen...

for casting stronger gray iron

Smart foundrymen know that strong, dense castings are in demand by production industries seeking to keep machining costs down and production up. Many have found that FERROCARBO® Briquettes for cupola treatment is the answer. Get the whole story in this concise, fully-illustrated Technical Manual which will assist you to obtain optimum quality in the gray iron castings that you produce.

FERROCARBO®—its effect on machinability

In those industries where gray iron castings are utilized, the castings usually undergo many machining operations. The cost of these operations may amount to several times that of the casting. Consequently, the casting buyer finds that, in order to keep these costs down and production up, he must procure the best castings obtainable. FERROCARBO makes this possible through increased machinability and uniform structure leading to greater tool life and fewer costly down time delays.

The use of FERROCARBO Briquettes for cupola treatment is an effective means for increasing production through improved casting machinability.

STRUCTURE DETERMINES MACHINABILITY

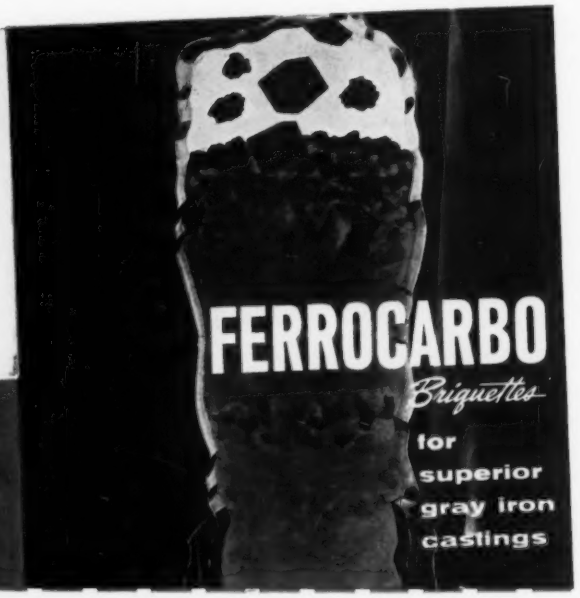
In the past, gray iron casting buyers have used hardness measurements to predict the machinability of castings. However, hardness measurements are not entirely reliable for this purpose, since hardness is only indicative of and not directly related to machinability. U. S. Government tests and production experience demonstrate conclusively that machinability is primarily determined by the microstructure. Therefore, structure control is of the utmost importance to the buyer. The relative machinability of some important microconstituents of gray cast iron, in the order of decreasing machinability, are graphite, ferrite, coarse pearlite, fine pearlite, acicular structure, iron sulphides, iron phosphides (steadite), and iron carbides (cementite). The machinability is determined by the type, amount, and distribution of these constituents.

Figure A

Figure B

The photomicrographs shown above of two gray irons of similar chemistry [illegible] of FERROCARBO treatment. Figure A depicts a typical microstructure which [illegible] able, is not satisfactory for many applications. In contrast, FERROCARBO [illegible] shown in Figure B exhibits a microstructure possessing improved basic and [illegible] high strength. In addition, due to the FERROCARBO treatment, this [illegible] produces machinability superior to that of the untreated iron shown in Figure [illegible]

YOUR COPY IS WAITING FOR YOU. MAIL COUPON NOW...TODAY



THE CARBORUNDUM COMPANY
Dept. M-813, Niagara Falls, New York

Please send me my copy of "FERROCARBO Briquettes For Improved Microstructure and Machinability of Gray Iron."

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february, 1959
vol. 35, no. 2

modern castings

the technical magazine of the metalcasting industry

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2-6 . . American Society for Testing Materials, *Committee Week Meeting*. Penn-Sheraton Hotel, Pittsburgh, Pa.

11 . . AFS Board of Directors, *Spring Meeting*. Palmer House, Chicago.

12-13 . . AFS *Wisconsin Regional Foundry Conference*. Schroeder Hotel, Milwaukee.

15-19 . . American Institute of Mining, Metallurgical & Petroleum Engineers, *Annual Meeting*. Palace Hotel, San Francisco.

18-19 . . Malleable Founders' Society, *Technical & Operating Conference*. Wade Park Manor, Cleveland.

26-27 . . AFS *Southeastern Regional Foundry Conference*. Hotel Tutwiler, Birmingham, Ala.

MARCH

9-10 . . Steel Founders' Society of America, *Annual Meeting*. Drake Hotel, Chicago.

13-14 . . AFS *California Regional Foundry Conference*. Huntington-Sheraton Hotel, Pasadena, Calif.

16-20 . . American Society for Metals, *11th Western Metal Exposition & Congress*. Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles.

17-19 . . National Association of Corrosion Engineers, *Annual Conference & Show*. Sherman Hotel, Chicago.

17-19 . . Investment Casting Institute, *Technical Session*. Surf Rider Inn, Santa Monica, Calif.

18-19 . . Foundry Educational Foundation, *Annual College-Industry Conference*. Hotel Statler-Hilton, Cleveland.

19-20 . . AFS *Texas Regional Foundry Conference*. Menger Hotel, San Antonio, Texas.

APRIL

5-10 . . American Chemical Society, *Spring Meeting*. Boston.

6-8 . . American Institute of Mining, Metallurgical & Petroleum Engineers, *National Open Hearth Steel Conference*. Hotel Jefferson, St. Louis.

6-10 . . American Welding Society, *Annual Meeting and Welding Exposition*. Hotel Sherman, Chicago.

8-9 . . Malleable Founders' Society, *Market Development Conference*. Hotel Cleveland, Cleveland.

13-17 . . AFS *Engineered Castings Show and 63d Annual Castings Congress*. Hotels Sherman and Morrison, Chicago.

18-22 . . American Society of Tool Engineers, *Annual Meeting*. Schroeder Hotel, Milwaukee.

MAY

13-15 . . National Industrial Sand Association, *Annual Meeting*. The Homestead, Hot Springs, Va.

17-21 . . American Ceramic Society, *Annual Meeting*. Palmer House, Chicago.

25-26 . . Malleable Founders' Society, *Annual Meeting*. The Homestead, Hot Springs, Va.

27-28 . . American Iron and Steel Institute, *Annual Meeting*. Waldorf-Astoria Hotel, New York.

JUNE

9-12 . . Material Handling Institute, *Exposition*. Public Auditorium, Cleveland.

11-12 . . AFS *Chapter Officers Conference*. AFS Headquarters, Des Plaines, Ill. and Sherman Hotel, Chicago.

18-20 . . AFS *Foundry Instructors Seminar*. University of Illinois, Urbana, Ill.

21-26 . . American Society for Testing Materials, *Annual Meeting*. Chalfonte-Haddon Hall, Atlantic City, N. J.

25-27 . . AFS *Penn State Foundry Conference*. Pennsylvania State University, University Park, Pa.

SEPTEMBER

24-26 . . AFS *Missouri Valley Regional Foundry Conference*. Missouri School of Mines, Rolla, Mo.

28-Oct. 1 . . Association of Iron and Steel Engineers, *Annual Convention*. Sherman Hotel, Chicago.

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	FOUNDREZ 7600, 7601, 7605	LIQUID AMINO CORE BINDING RESINS	RAPID COLLAPSIBILITY FAST BAKE — LESS SMOKING
	CO-RELEES 7300	LIQUID SAND CONDITIONER	EXCELLENT SAND WORKABILITY
	coRCIment 7990, 7991, 7992, 7993	LIQUID OLEORESINOUS CORE BINDERS	BROAD BAKING RANGE
	FOUNDREZ 7150, 7151	LIQUID PHENOLIC RESINS FOR SHELL COREMAKING	UNUSUAL STABILITY
	FOUNDREZ 7500, 7504, 7506, 7555	POWDERED PHENOLIC RESINS FOR SHELL MOLDING	SELF-ACTIVATION
	FOUNDREZ 7520	GRANULATED PHENOLIC RESIN FOR SHELL MOLDING	HIGH TENSILE STRENGTH
	COROVIT 7201, 7204	POWDERED ACCELERATORS FOR COROVIT OILS	NON-TOXICITY
	COROVIT 7202, 7203	LIQUID BINDERS (SELF-CURING)	EXCELLENT FLOWABILITY
STEEL STAINLESS LOW CARBON HIGH CARBON	**FOUNDREZ** 7104	LIQUID PHENOLIC CORE BINDING RESIN	EXCEPTIONAL STABILITY HIGH HOT STRENGTH HIGH BAKED STRENGTH
COPPER ALLOYS BRASS BRONZE	**FOUNDREZ** 7605	LIQUID AMINO CORE BINDING RESIN	FAST BAKE LESS SMOKING
LIGHT ALLOYS ALUMINUM MAGNESIUM	**FOUNDREZ** 7605	LIQUID AMINO CORE BINDING RESIN	RAPID COLLAPSIBILITY

Creative Chemistry . . .
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REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

Circle No. 479, Page 151-152

NATIONAL MOLDER'S HELPER

It's an aerator!

Upper section of "Elevayor" automatically aerates sand. Another step eliminated, another item of equipment and labor that's *built-in* with this low cost mechanized National "package" unit.

It's an "Elevayor"

This unique National-patented equipment item will deliver a full mixer batch from discharge door to bin within 20-30 seconds. Can be designed to receive charge from front end loader too. Shoveling or extra handling is *completely* eliminated.

It's overhead sand

Sturdy, NATIONAL Molder's Hoppers receive fluffy, aerated free-flowing sand ready for molding — in seconds. Units available for 2, 4 or 6 molders stations. Riddling and shoveling are eliminated to cut molder's time up to 50%.

Use it with any Mix-Muller

You've already cut your costs if you're now a Mix-Muller user! Molder's Helper can be used with any Model Mix-Muller (1F to 2½F)

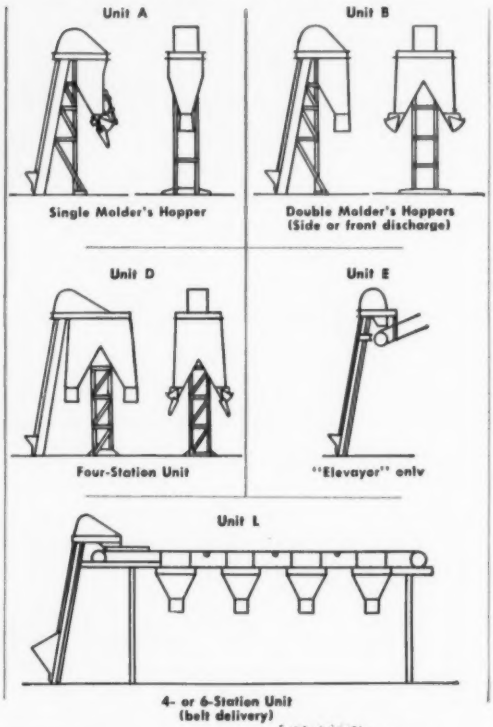
It's National Quality

The Molder's Helper is a *foundry* proven item. Its design, fabrication and performance characteristics reflect the same quality of workmanship that is found in all National-engineered components.

Molder's Helper with 1½F Mix-Muller handles 1000 lb. batch. Is equipped with two 50 cu. ft. hoppers.

Many arrangements possible

Other arrangements available to suit specific requirements.



Now any foundry can afford to have overhead sand!

The National Molder's Helper is designed to eliminate the costly time and labor consuming job of hauling sand from mixer to molder. With it, you can bring overhead sand to the smallest operation; *increase* molders production up to 50%; *eliminate* floor shoveling and *concentrate* your entire mixing and molding operation into no more floor space than one molder now occupies.

Cold hard *dollars* saved in increased efficiency, lower labor costs and better, more flowable sand—can quickly pay the small cost of the Molder's Helper. *But what's more* any foundry with a Simpson Mix-Muller already has a head start in equipment. Write for further details today, or let your man from NATIONAL give you an estimate.

NATIONAL ENGINEERING COMPANY

630 Machinery Hall Bldg.

Chicago 6, Illinois

Circle No. 480, Page 151-152

ANOTHER! PROVEN PRODUCT OF THE PRACTICAL FOUNDRYMAN BY NATIONAL

the editor's report

by Jack Schaum

■ **Is snow removal one of your foundry material handling problems?**
Here's how . . .
Minneapolis Electric Steel Castings Co. uses a special truck-carried hopper to do the job.
Just lower the boom . . .
push open-end tote box into snow drift . . .
raise snow load . . .
and away you go.

■ **Watch** for your special March issue of MODERN CASTINGS! You'll want to see that your customers get this **Guide to Designing and Buying Castings.** Eight articles will tell when, where and why to use metalcastings to meet product demands.

■ **Wear on mating surfaces of tight flasks** . . . has practically been eliminated by molding a **thin rubber strip** on the flask-bearing surface of pattern plates. Inventor, Richard L. Olson, says the cushioning effect of this rubber also **stops** the **noise** generally attributed to metal-metal contact in jolt-squeze molding.

■ **A new cast engineering material** . . . termed Centrasteel — a high modulus cast graphitic steel . . . will be announced in a feature article appearing in March issue of MODERN CASTINGS. Central Foundry Division, GMC, will describe the production techniques and applications for this unusual metalcasting material that **combines characteristics of steel, malleable iron and ductile iron.**

■ **One pound of weight** . . . saved on a casting in a **ballistic missile** adds 18,000 ft to its range! And a pound saved in the third stage rocket of a space vehicle reduces fuel requirements by 1000 lb!

■ **Special anodized aluminum permanent molds** are being used successfully for producing titanium castings. Same type mold is also being used for **casting tank track shoes** in alloy 195 for air-borne military tank.
The permanent mold is said to give superior metal structure for optimum physical properties with consistent reliability. Pictured here is an AZ91C magnesium turbine housing casting (foreground), as-cast (center) and the two-piece mold (background).

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Build an idea-file for improvement and profit. The post-free cards *on the last page* will bring more information on these new . . .

products and processes

SELF-CURING BINDER . . . for foundry core sand said to mix more rapidly with sand and to provide greater sand flowability and workability. Manufacturer states new binder is easy to handle in the foundry and shows little tendency to "skin over" in drums or during storage. *Reichhold Chemicals, Inc.*

For Manufacturer's Information Circle No. 281, Page 151-152

SILICONE MOLD RELEASE . . . and lubricant reportedly eliminates

sticky and marked molds in shell molding operation. *Para Products.*

For Manufacturer's Information Circle No. 282, Page 151-152

METAL DISTRIBUTOR . . . designed to allow one man to pour large floor area faster than two or more men using hand ladle pouring, say company officials. Advantages include; one-hand control, pouring ease, brake for holding load at any position and minimum of moving parts. *Industrial Equipment Co.*

For Manufacturer's Information Circle No. 283, Page 151-152

LADLE FEEDER . . . for making ferro-manganese or other alloy additions to the ladle while steel is being tapped. Officials state it is not necessary to weigh alloys going into hoppers as operator sets unit to deliver specific amounts. Rate also controlled. Designed to eliminate shoveling and hauling of alloy additives, allowing more time for tending to furnace bottom and tap hole conditions. *Blaw-Knox Co.*

For Manufacturer's Information Circle No. 284, Page 151-152

BIN VIBRATORS . . . provide pinpoint vibration claimed to eliminate clogging, bridging or packing of granular, lumpy or powdered material. *Eriez Mfg. Co.*

For Manufacturer's Information Circle No. 308, Page 151-152

BELT CONVEYORS . . . supported on rollers strung between parallel stringers of steel wire rope eliminate rigid support framing. Results, according to manufacturer, are lower costs, simple installation and reduced maintenance; they also state conveyor is easy to re-locate or extend. *Joy Mfg. Co.*

For Manufacturer's Information Circle No. 285, Page 151-152

HOISTS . . . utilize hydraulic power to raise loads up to 10 ft at speeds reportedly up to three times that of conventional hoists. Features are precision positioning, adjustable-speed action, one-hand operation and finger-tip control, according to company officials. Four sizes, 1/4, 1/2, 1 and 2-ton capacities. *Borg-Warner Corp., Pesco Products Div.*

For Manufacturer's Information Circle No. 286, Page 151-152

ALUMINUM SOLDERING ROD . . . requires no flux, washing or wire brushing. No cleaning needed, either before or after use, officials report.

Applied by rubbing across joints which have been heated. *Air Reduction Sales Co.*

For Manufacturer's Information Circle No. 287, Page 151-152

HOT-MATERIAL CONVEYOR . . . vibrating action, designed to handle materials up to 1800 F. Conveyors feature unrestricted expansion and contraction of troughs. According to manufacturer, thermal stresses are not added to the mechanical stresses of structural members or supporting coil springs, adding to efficiency of hot and abrasive materials conveying. *Carrier Conveyor Corp.*

For Manufacturer's Information Circle No. 288, Page 151-152

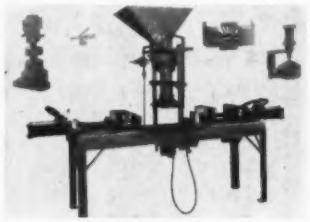
FRONT-END LOADER . . . features 9000-lb capacity, both gas and diesel powered. New low profile said to offer operator improved visibility. Also features patented pry-out bucket action. *Frank G. Hough Co.*

For Manufacturer's Information Circle No. 289, Page 151-152

CHAIN HOISTS . . . said to be ideal for outdoor use or where portability and headroom is a prime consideration. Fabricated of lightweight aluminum alloy, unit features minimum weight and great strength—1/4, 1/2 and 1-ton capacities. *Manning, Maxwell & Moore Inc.*

For Manufacturer's Information Circle No. 290, Page 151-152

CORE BLOWER . . . manufacturer states it is now possible to convert many of present core boxes into shell



cores. Machine produces shell cores up to 10-in. dia and 12-in. height. *Harrison Machine Co.*

For Manufacturer's Information Circle No. 291, page 151-152

BLOWGUN . . . for cleaning chips, dirt or sand from work surfaces is designed for overhead suspension and for use in cramped areas. Said to incorporate feature wherein air stream forms protective screen shielding operator from flyback. *E. V. Nielsen, Inc.*

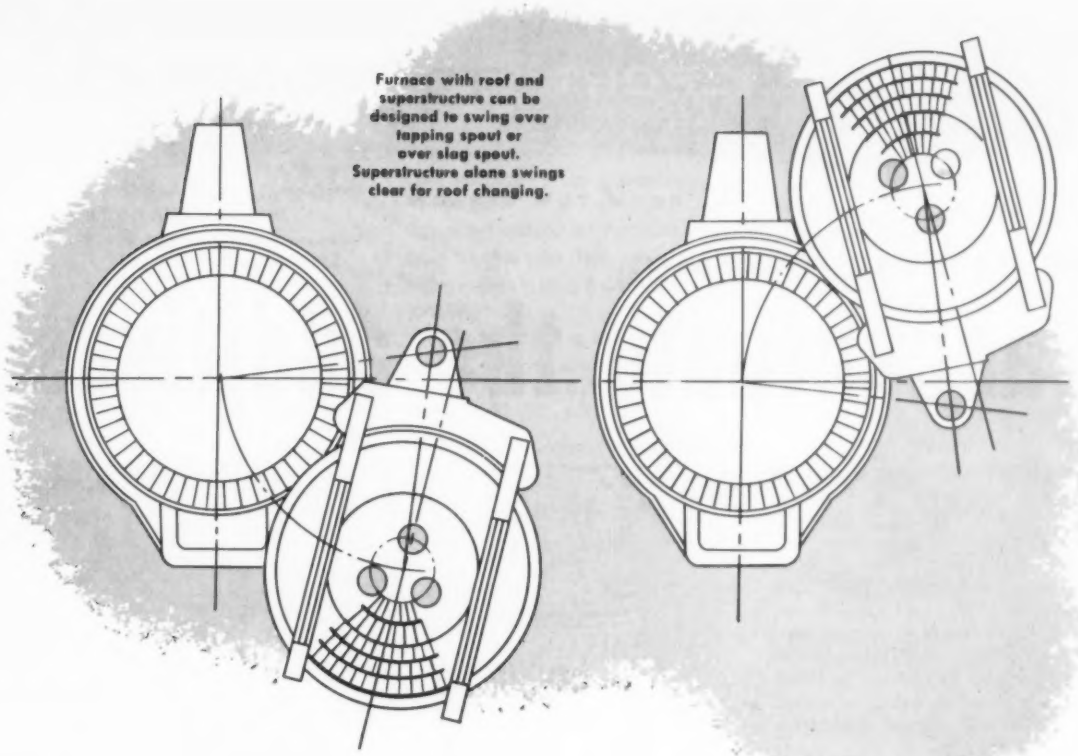
For Manufacturer's Information Circle No. 292, Page 151-152

TABLE BLAST PADS . . . designed to withstand abrasion, impact and corrosion reportedly outlast other types, cutting table blast wear to a minimum. *A.I.C. Engineering Co.*

For Manufacturer's Information Circle No. 293, Page 151-152

HIGH TEMPERATURE ALLOY . . . claimed by manufacturer to produce castings making possible higher jet engine and airframe Mach numbers at lower specific weight because of

Continued on page 10


Furnace with roof and superstructure can be designed to swing over tapping spout or over slag spout. Superstructure alone swings clear for roof changing.

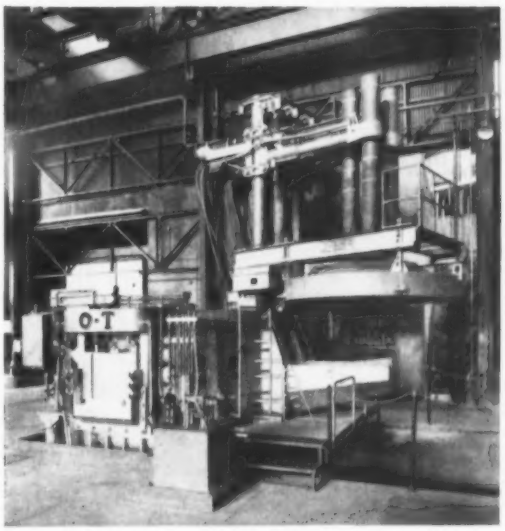
With a Lectromelt Furnace you have a choice

THE ROOF CAN BE BUILT FOR FRONT OR BACK SWING

SELECT the direction of swing that best fits your plant layout—over the tapping spout or over the slag spout. Lectromelt's design and method of separately supporting the roof structure makes this possible. You profit by the greater efficiency and convenience that result.

Note in the above drawing how the furnace top swings clear of the furnace; there's no interference with the charging bucket to slow down the charging operation. Lectromelt places the pivot point away from the furnace shell to accomplish this. And, because the swing of the top can be less, there's less strain on the conductors.

Catalog No. 10 describes Lectromelt furnaces. For a copy write Lectromelt Furnace Division, McGraw-Edison Company, 316 32nd Street, Pittsburgh 30, Pennsylvania.



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STANDARD SIZES UP TO TWO HUNDRED TONS CAPACITY

CANADA: Canefco Limited, Toronto . . . ARGENTINA: Master Argentina, Buenos Aires . . . ITALY: Forni Stein, Genova . . . ENGLAND: Electric Furnace Co., Ltd., Weybridge . . . GERMANY: Demag-Elektrometallurgie, GmbH, Duisburg . . . SPAIN: General Electrica Espanola, Bilbao . . . FRANCE: Stein et Roubaix, Paris . . . BELGIUM: S. A. Stein & Roubaix, Bressoux-Liege . . . JAPAN: Daido Steel Company, Ltd., Nagoya

Circle No. 481, Page 151-152

International Minerals & Chemicals

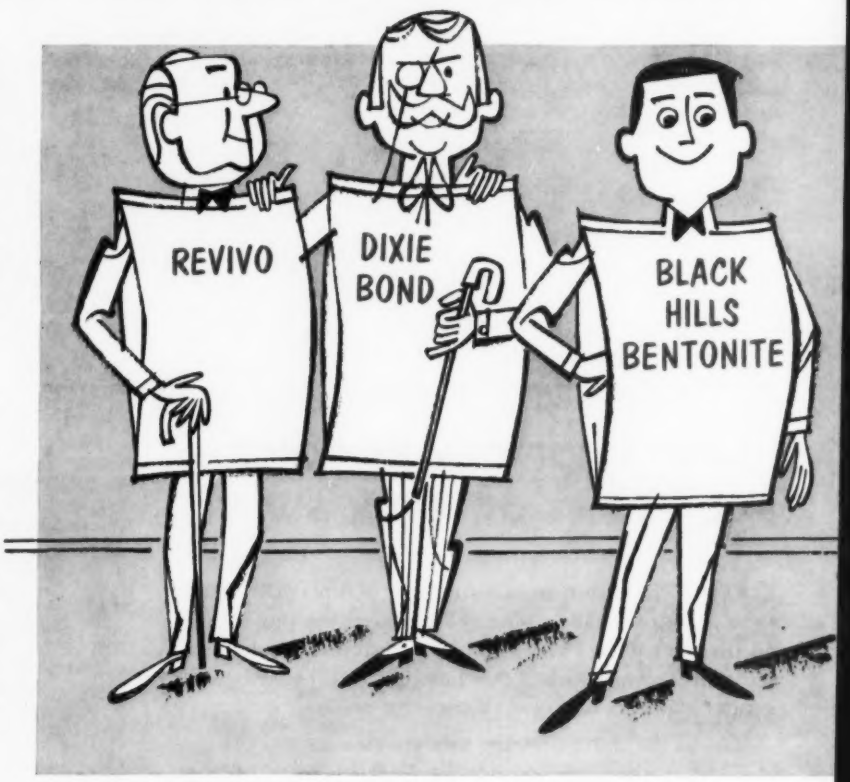
A REPORT TO FOUNDRIES

FROM TOM BARLOW

The trend in molding:

accentuate the additives

In green sand molding, progress is more apt to be a matter of evolution than revolution. Changes have been so gradual that we sometimes fail to notice how drastic a difference the last thirty years have made. Did you ever meet and old schoolmate after twenty years and notice how much *he* had changed? In the same way, a Rip Van Winkle of molding would be startled by what he would see today — The Age of Additives.



Age of Natural Sand

Sand practice has come through at least three distinct phases — with minor but important growths within each period. By-passing ancient history, we can start with the Age of Natural Sand. During this time, the only molding sands were mixtures of sand, clay, silt and miscellany as they occurred in nature. These sands are still used and probably always will be for special applications and/or shops without adequate sand conditioning equipment. They were easy to control because there was nothing *to* control — other than the source from which you bought them.

Age of Synthetic Sand

The introduction of Revivo (to revive worn-out sand) by ECP was a pioneering move toward the Age of Synthetic Sand. At first, the bonding clays were added to used natural sand (today we call these semi-synthetic). Later foundries started with clean sand and added sea-coal, pitch, etc. Western Bentonite produced somewhat different properties and advanced a little farther from the parent natural-sand values. Lower moisture, high toughness and more permeability became the order of the day. Soon N. J. Dunbeck (of Eastern Clay Products) introduced and patented the use of southern bentonite (known then and now as Dixie Bond). More flowability and permeability with lower hot and dry strengths opened up new possibilities. Today, foundrymen recognize that no one clay can be best for every application. To be impartial in our service and sales work, we produce all three (and some combinations, such as Balanced Revivo).

Now—the Age of Additives

We now approach the Age of Additives which probably dates back to ECP's introduction of Westonite, the original waterless molding sand. The purpose of this program was to combine flowability, toughness and strength in the same sand. This cannot be done by clay alone! When synthetic sand was young, many people thought only in terms of one clay—only one way to skin the cat. They now know there are many — each with its own virtues. For example, Dixie Bond is not a direct substitute for Black Hills Bentonite and vice versa. The same philosophy is true of flowability additives. No one can do all jobs equally well. They vary considerably in their effect on green strength, hot strength, dry strength and impact strength.

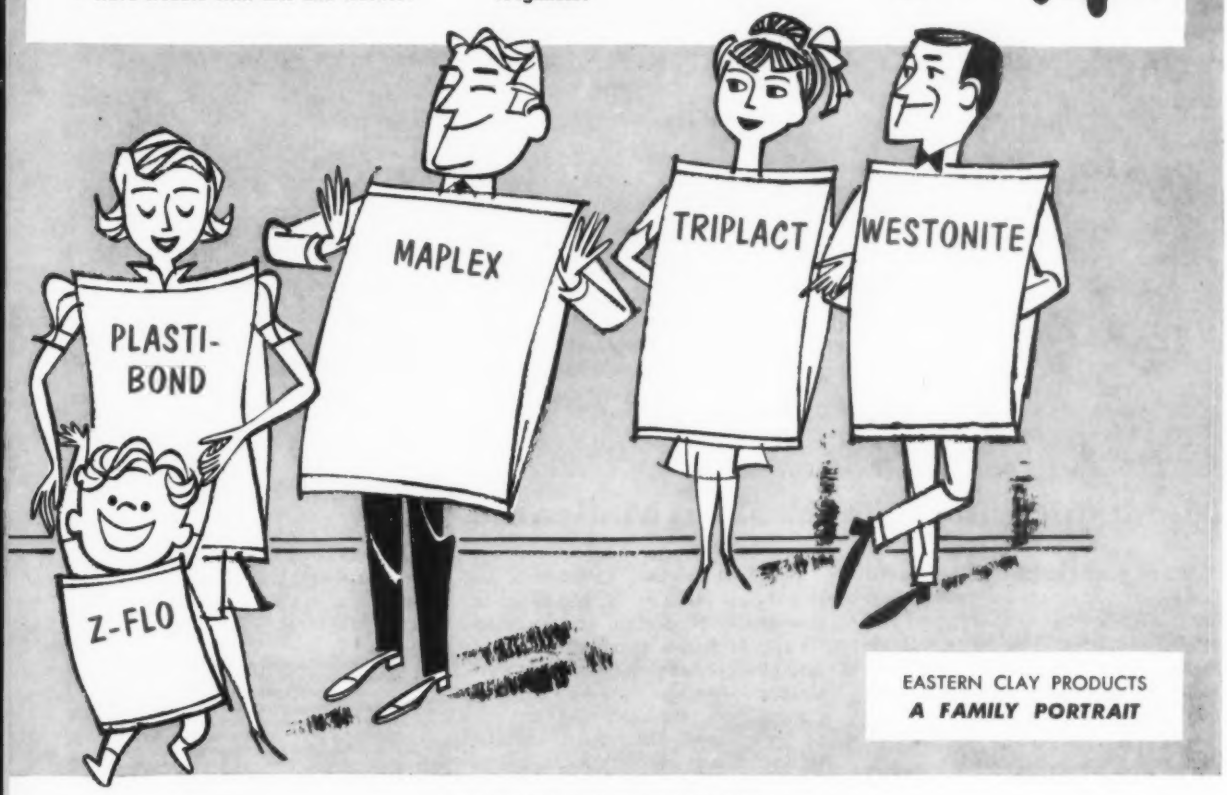
Circle No. 482, Page 151-152

NEW CHIP OFF THE OLD FAMILY TREE

Have a cigar! There's a new addition to the line of Eastern Clay additives — Z-Flo. Following is a word picture of the type of foundry that might profitably adopt the baby. If one or more of these shoes fit you, why don't we discuss it in person — in detail.

DO YOU . . .

- Require a versatile sand?
- Use a slurry system of clay addition?
- Have trouble with cuts and washes?
- Want a sand that isn't waterproof?
- Require a high-durability additive?
- Lack adequate mulling time or equipment?
- Use either natural or synthetic sand?
- Have trouble with deep pockets?
- Have broken molds from rough handling?
- Use too many facing sands?
- Want to use more Dixie to reduce costs and still want good dry strength and toughness?



EASTERN CLAY PRODUCTS
A FAMILY PORTRAIT

In this Age of Additives, there's a *best* additive for what *you* do. We have the entire range to work with and the know-how to make impartial and accurate recommendations. Our research, experience and desire to serve may help you make more money through better castings.

ALL IN THE FAMILY

Here's a picture of molding progress through the last 20 years. Westonite triggered the Age of Additives. Today — in addition to Maplex (pure hard maple flour) — we insist on producing three distinct grades of additives for better finish, better peel, better casting tolerance and reduced casting defects. In future columns, we will clarify the differences between them, based on both research data and operating experiences. You will have the chance to determine for yourself what member of the Eastern Clay Products family is of greatest interest to you. Don't miss the next exciting episode in the lives of the additive family. The cast includes: TRIPLACT, the oldest; PLASTI-BOND, the most popular; Z-FLO, baby of the family.

Creators of
Living Minerals

EASTERN CLAY PRODUCTS DEPT.

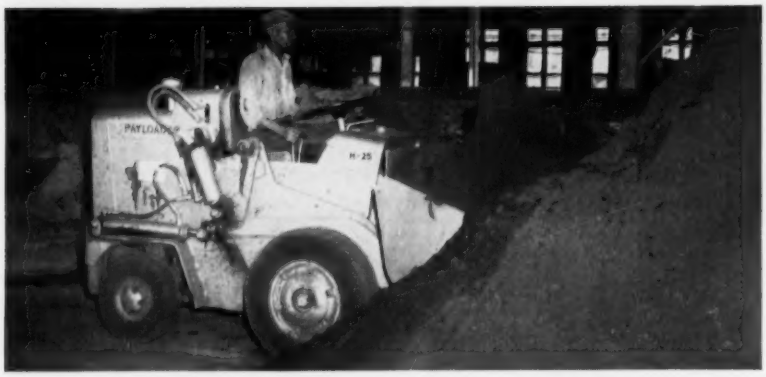
INTERNATIONAL MINERALS & CHEMICAL CORPORATION

Administrative Center, Old Orchard Road, Skokie, Illinois • ORchard 6-3000

1-59

Circle No. 482, Page 151-152

Two-way Sand-handling System



No "dead-heading" at Eastern Malleable

When your sand has to be moved long distances between preparation area and the points of use you can take a tip from The Eastern Malleable Iron Co.'s Wilmington, Del. foundry where these hauls are about 600 feet.

They solved this problem with the use of speedy, high-capacity "PAYLOADER" tractor-shovels and a set-up that practically eliminates all "dead-heading" or travel without payload. So the "PAYLOADER" units are able to scoop up sand from the pouring floor, carry it 600 feet to the shaker, re-load with prepared sand from the nearby pile for the return trip and deliver it to any of the 35 molding stations.

Eastern's newest "PAYLOADER" is this model H-25 — the last word in tractor-shovel design and productivity. It has a carry capacity of 2,500 lbs., it has power-steer, power-shift transmission with two speed ranges both forward and reverse, power-transfer differential and the fullest system of air and oil filters and grease seals for long-life protection and low maintenance.

Your "PAYLOADER" Distributor is ready to give you all the facts on the H-25 or any other "PAYLOADER" models that best fit your needs.

HOUGH

THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

The FRANK G. HOUGH Co. 2-A-2
711 Sunnyside Ave.
Libertyville, Ill.

☐ Send me more data on Model H-25
☐ Other "PAYLOADER" units

Name_____
Title_____
Company_____
City_____
State_____

Circle No. 483, Page 151-152

products and processes

Continued from page 6

alloy's high temperature capability. The new nickel base, titanium-aluminum hardened alloy is designed for use in the 1800 F range. Company's specification contains stress rupture requirement of 25-hr. minimum life when tested at 1650 F and 25,000 psi. *General Electric Co.*

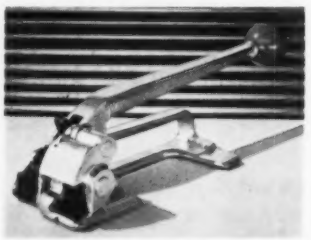
For Manufacturer's Information Circle No. 294, Page 151-152

TABLE-ROOM CLEANING . . . unit features sealing system claimed to make cabinet abrasive-tight without rubber gaskets. Table designed to clean castings up to 72 in. in dia and

36 in. high, weighing up to 5000 lb. Thirty-hp motor powers single blasting wheel which will throw 50,000 lb of abrasive per hr. *Pangborn Corp.*

For Manufacturer's Information Circle No. 295, Page 151-152

STEEL STRAPPING TIGHTENER . . . reportedly engineered to require fewer strokes and to operate with exceptional ease in tensioning steel



strapping to required maximum. May be operated in any position and will strap in any direction. *Stanley Steel Strapping, Div. Stanley Works.*

For Manufacturer's Information Circle No. 296, Page 151-152

PRECISION FORMING PROCESS . . . can reportedly produce up to 50,000 parts a day in almost all castable metals and alloys. Process is said to successfully combine basic advantages of investment casting with those of coining, cold forming, screw

Continued on page 12

VANADIUM
CORPORATION
OF AMERICA

"True, some silicon products are 'cheaper' than others . . ."

. . . But the "cheaper" product may cost you more in the long run! Real economy and efficiency come only when the *right* silicon product is mated with the *right* application. Often, because silicon has so many different uses, it's not so easy to select the product that will give best results — at lowest final cost.

That's where your VCA representative comes in. He can be a real help in determining the ideal form and type of silicon for the job you have to do. And the reason he's so well qualified is that VCA offers a complete line of silicon products — and *knows* its line! Get an impartial recommendation that can mean significant savings in your operations. Call your nearest VCA district office soon! Vanadium Corporation of America, 420 Lexington Avenue, New York 17, N. Y.
Chicago • Cleveland • Detroit • Pittsburgh

Circle No. 484, Page 151-152

More and More Foundries are making TRACKS to *Famous* CORNELL CUPOLA FLUX

for Gray Iron and Malleable Foundries

don't accept substitutes

Wherever the achievements of Famous Cornell Cupola Flux are known—its uniform purity, its ability to continually produce sounder, cleaner castings—you'll find a good stock of Famous Cornell Flux! Write for Bulletin 46-B.

The Benefits . . . The Advantages of Famous CORNELL Aluminum, Copper or Brass Flux

Write for Bulletin 46-A.

DAWSON-MacDONALD CO.
141 PEARL STREET, BOSTON 10, MASS.
Now Representing The Cleveland Flux Company in New England.

FAMOUS CORNELL FLUXES

Trade Mark Registered

The CLEVELAND FLUX *Company*

1026-40 MAIN AVENUE, N. W. • CLEVELAND 13, OHIO

Manufacturers of Iron, Semi-Steel, Malleable, Brass, Bronze, Aluminum and Ladle Fluxes—Since 1918

Circle No. 485, Page 151-152

products and processes

Continued from page 10

machine production, etc. Company also claims dimensional tolerances to plus or minus 0.001-in. per in. and superior surface finish. *Casting Engineers Inc.*

For Manufacturer's Information Circle No. 297, Page 151-152

PORTABLE MOLD DRIER . . . circulates air under pressure at controlled temperature throughout mold cavity. Manufacturer states unit dries all mold surfaces quickly and uniformly; placed in operation by connecting to fuel and electric services. *Foundry Equipment Co.*

For Manufacturer's Information Circle No. 298, Page 151-152

why worry? circle numbers of these items on the reader service card, last page, and you'll know more about your industry than **anybody!**

NEW CASTABLE ALLOY . . . reportedly develops 40,000-50,000 psi tensile strength; 35,000-37,000 psi yield strength; and elongation 6 to 10 per cent. Also said to possess good castability. *Reynolds Metals Co.*

For Manufacturer's Information Circle No. 299, Page 151-152

SELF-DUMPING HOPPER . . . for flexibility in handling all types of foundry bulk materials: sand, scrap, coke, limestone. Ventilated model for handling of hot castings. Designed for easy stacking, one upon another, and for self dumping and return to upright position. *Apex Welding & Fabricating Corp.*

For Manufacturer's Information Circle No. 300, Page 151-152

DIE-CAST RELEASE AGENT . . . designed to end costly die cleaning and polishing due to carbon deposits, and to contribute to more fill-out in deep-cored areas. Product completely eliminates carbon deposits, according to manufacture. *Chemical Products Div., American Charcoal Co.*

For Manufacturer's Information Circle No. 301, Page 151-152

METAL REMOVAL . . . torch for light maintenance work operates on 40 psi. Features positive air control valve in torch handle. *Arcair Co.*

For Manufacturer's Information Circle No. 302, Page 151-152

SPRAY LUBRICANT . . . for gears offered in push button aerosol cans.

Continued on page 14

Speed production of grey iron castings

EXCELLENT FLOWABILITY of Dexocor binder sand mix gives uniform structure throughout cores—and draws are made easily without sticking.

A large midwestern grey iron foundry finds that:

*"Cores made with Dexocor baked through in 40 to 50 per cent less time—saving fuel dollars and permitting more flexible production scheduling. In addition, green cores, even with high stands or overhang, held perfect shape. Cracking of cores, gas defects and metal penetration were virtually eliminated."

—Dexocor offers other advantages: Better moisture control, excellent flowability, quick, easy mixing, blowing, ramming, easy shake-out—especially when used with Mogul or Kordek binder.

Ask for detailed information and technical help in utilizing this new miracle binder. Contact our nearest sales office.

*Source on request.

DEXOCOR® Binder

Other fine products for the Foundry Industry: MOGUL® and KORDEK® Binders • GLOBE® Dextrines

CORN PRODUCTS SALES COMPANY 17 BATTERY PLACE, NEW YORK 4, N.Y.

Circle No. 486, Page 151-152

WOODWARD IRON COMPANY

Established 1882

We are proud of our long association with the Woodward Iron Company, Woodward, Alabama.

Nationally known Woodward Iron, famed for its uniformity and strength, is the choice of many of America's leading foundries.

Where castings of highest quality are required, Woodward Iron will more than meet your specifications.

We invite your inquiries. We believe that you will like the outstanding service that the "Woodward-H-W" team will give you.

There is a Hickman-Williams office as near as your phone.

70th Year of Service to the Foundries of America

Established 1890

Hickman, Williams & Co.

CHICAGO • DETROIT • CINCINNATI • ST. LOUIS • NEW YORK
CLEVELAND • PHILADELPHIA • PITTSBURGH • INDIANAPOLIS
Established 1890

Circle No. 487, Page 151-152

products and processes

Continued from page 12

Protects open gears, chains, cams, wire rope, etc. Lubricant reportedly forms extremely tacky surface within minutes, redistributing itself over critical areas as gear turns, outlasting several ordinary coatings. Effective under wet, dry or dusty foundry conditions. *Acrolite Products, Inc.*

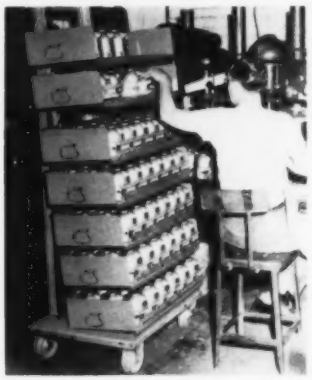
For Manufacturer's Information Circle No. 303, Page 151-152

PRECISION TEMPERATURE . . . measurement pyrometer designed for laboratory use, claimed to be sufficiently portable for general foundry applications. Company officials state unit combines higher accuracy with

greater versatility in measurement of temperatures over 1300 F. Capable of measuring targets less than 0.001-in. in diameter; can be adjusted for focal distances five in. to infinity. *Pyrometer Instrument Co.*

For Manufacturer's Information Circle No. 304, Page 151-152

PORTABLE, ADJUSTABLE RACK . . . holds up to seven removable trays designed to accommodate 500 lb each. Foundry applications include



inexpensive manual handling of cores or castings. Trays are height adjustable to allow for varying work sizes. *Hartman Metal Fabricators, Inc.*

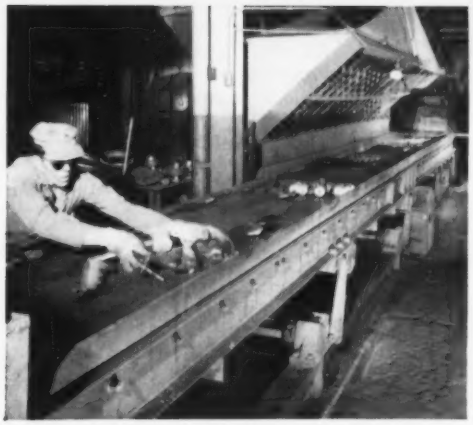
For Manufacturer's Information Circle No. 305, Page 151-152

SPHERICAL ROLLER BEARINGS . . . said to be highest capacity spherical roller bearings yet developed. New features include maximum diam-

Continued on page 16

Move to modernization

LINK-BELT TROLLEY MOLD CONVEYOR takes hot castings on a cooling ride. After a 340-ft. trip, castings are automatically discharged to Link-Belt oscillating conveyor.



LINK-BELT TORQMOUNT OSCILLATING CONVEYOR has perforated plate at receiving end for separating sand and castings. Castings then cool along 36-ft. route and are sprued and sorted near discharge end.

LINK-BELT trolley and oscillating conveyor work together to give Brillion Iron Works a cleaner, cooler, more productive foundry

Here's a Link-Belt conveyor combination that has worked wonders at this midwest gray iron foundry.

A Link-Belt trolley mold conveyor was easily installed around existing equipment, releasing floor space for storage and ventilating equipment . . . an addition that has eliminated much of the smoke and gas that existed in the pouring area. And with heavy lifting and carrying eliminated, working conditions are safer and easier . . . pouring and cooling are accomplished more efficiently.

From shakeout to sorting, hot castings move smoothly on a Link-Belt Torqmount oscillating conveyor. Its full-time positive action refuses to dampen under heavy surge loading conditions . . . castings are conveyed uniformly. Power requirements and maintenance are minimized with unique torsion-spring action.

Link-Belt offers unmatched experience plus a broad line of sand handling and preparation machinery to modernize any phase of your operation—or to equip a complete, new foundry. For further facts, contact your nearest Link-Belt office. Or write for Book 2423. 14,952

LINK-BELT

CONVEYORS AND PREPARATION EQUIPMENT

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants and Sales Offices in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

FOUNDRY EQUIPMENT MANUFACTURERS ASSOCIATION MEMBER FEMA

Circle No. 488, Page 151-152

America's leader in metal abrasives . . .

For over 70 years, Pittsburgh Crushed Steel Company has consistently led the metal abrasives industry—has led in research and product development—has led in the improvement of production methods—and has led in sales and service facilities as well as in distribution facilities!

The results have been better metal abrasives for lower cleaning costs in foundries, forge plants, and steel and metal working plants in general!

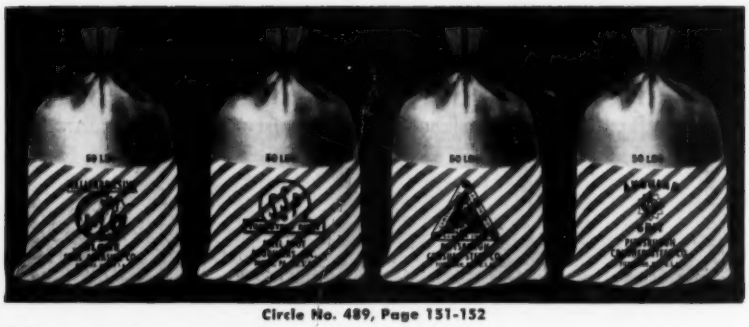
Today, through 13 distributing points and 33 sales-service offices, we supply all sizes and types of metal abrasives, iron and steel, for every type of blast-cleaning equipment and for every blast-cleaning requirement!

Our engineering, sales, and service representatives are always available to you in connection with your blast-cleaning needs.

PITTSBURGH CRUSHED STEEL COMPANY

Arsenal Sta. Pittsburgh (1), Pa.
Subsidiaries: Globe Steel Abrasive Co., Mansfield, Ohio
Steel Shot Producers, Arsenal Sta. Pittsburgh, Pa.

MALLEABRASIVE | **TRU-STEEL SHOT** | **SAMSON SHOT** | **ANGULAR GRIT**



Circle No. 489, Page 151-152

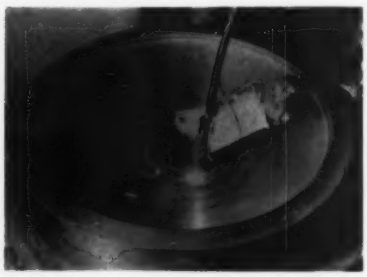
Continued from page 14

eter and quantity of convex rollers for each bearing size; precision machined centrifugally-cast retainers; and high, inner race shoulders. These features reportedly assure optimum balance, and long, quiet performance on the most severe foundry installations. *Link-Belt Co.*

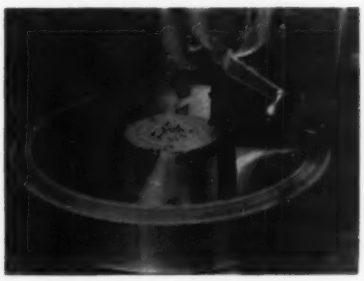
For Manufacturer's Information Circle No. 306, Page 151-152

product report . . .

Perfect welding . . . was needed in surfacing two steel tube sheets and a steel floating head with aluminum-bronze for Olmstede Machine Works, Inc., Beaumont, Texas. Total surfacing time for the three operations was only 50 hr due to deposition rate of six lb of metal per hr.



The Ohmstede plant selected the Sigma welding process, Linde Co., Div. Union Carbide Corp., New York, because, according to Bob Ohmstede, vice-president, "they had to produce a homogenous deposit completely free of slag and porosity."



Because of very rigid specifications as to iron content, a special welding technique was needed to reduce the amount of dilution. The problem was solved by 1) synchronizing a 3/4-in. torch oscillation with the turning speed of the welding fixture, and 2) carefully maintaining a 5/16 to 3/8-in. arc length.

The weld zone was shielded from atmosphere contamination by Linde argon gas. Over 300 lb. of aluminum-bronze wire were deposited.

For Manufacturer's Information Circle No. 307, Page 151-152

MODERN CASTINGS MAGAZINE IS YOUR INSIDE TRACK TO THE 63d AFS CASTINGS CONGRESS AND ENGINEERED CASTINGS SHOW

(Chicago, April 13-17, 1959)

BEFORE YOU COME TO THE SHOW

The April OFFICIAL CONVENTION ISSUE will give you information that will help you plan your Convention schedule . . . information such as –

- Schedule of events
- Briefs on Convention personalities and industry leaders
- Preprints of many papers to be given at the Congress
- Preview of new applications, latest machines and materials

MODERN CASTINGS will reach you at your regular mailing address when you have time to study and plan for the coming exhibits and events in Chicago. It will be a reliable guide for you as a foundryman as well as for the thousands of product-design engineers who will be AFS guests at the Show.

AFTER YOU ARE HOME FROM THE SHOW

The May CONVENTION REPORT ISSUE will review what you didn't have time to see completely yourself, reporting in detail the happenings and exhibits of the important five-day meeting that only MODERN CASTINGS' entire staff will have time to cover fully. Among the special features of the issue are –

- Data on the kinds of castings in which buyers show most interest
- Over-all summary of major trends in the metalcastings field
- Reports of latest metalcastings research
- Picture record of the Show

The April and May Convention Issues of MODERN CASTINGS are the greatest single source of reliable technical information . . . industry news . . . and practical working foundry data of the year.

WATCH FOR THESE IMPORTANT ISSUES SO YOU CAN GEAR YOUR THINKING TO THE 1959 UPSWING!

ADVERTISERS –

The entire metalcasting industry will look to the Official AFS Magazine for official news about the AFS Convention. These special-purpose issues are your only opportunity for a direct tie-in to this event. Include these important issues in your advertising schedule at regular rates!

modern castings

AFS TECHNICAL CENTER **DES PLAINES, ILLINOIS**

WHEELABRATOR® STEEL SHOT

cuts abrasive costs for

ALL TYPES OF FOUNDRIES

Malleable Foundry Saves $12,000 Annually
Cuts Abrasive Consumption in half

Savings of $1,000.00 a month in abrasive cost are being made at Albion Malleable Iron Co., as a result of switching from a malleable type abrasive to Wheelabrator Steel Shot.

This foundry operates a battery of 8 Wheelabrator Tumblasts, cleaning a variety of regular and pearlitic malleable castings. Consumption of the malleable shot in these machines was at the rate of 20 tons a month. Since changing to Wheelabrator Steel Shot this has been decreased to 10 tons a month, for an annual saving of $12,000.00 on abrasive alone.

More than 1200 firms have standardized on Wheelabrator Steel Shot and are recording inpressive savings. Consistently harder, with greater resistance to breakdown, it lasts longer in use, cleans better, and reduces total cleaning costs.

Write today for Bulletin 89-B — free — for detailed information on Wheelabrator Steel Shot

WHEELABRATOR
CORPORATION

630 South Byrkit Street **Mishawaka, Indiana**

Canadian Offices: Scarborough (Toronto) — Montreal

World's Largest Manufacturer of Airless Blast Cleaning and Steel Abrasives

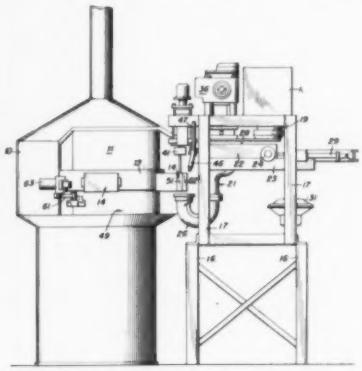
Circle No. 490, Page 151-152

patent review

Patents for coremakers

Shell core blower — 1

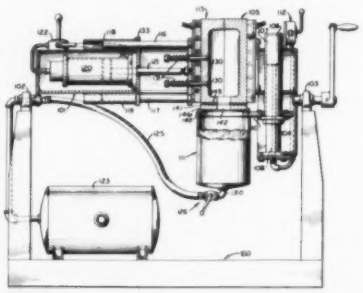
■ A shell core blower that automatically separates the two halves (51 and 52) of the core box (14) has been patented. Core boxes are moved into filling position by an index table (12) and are filled with a sand-resin mixture blown through a U-shaped horn (26). When the box is filled, it may be vibrated by the vibrator (46) so that excess sand



will fall back into the horn. Because the core box has been preheated by previous trips through the oven (10) a partially cured, hollow, shell core has now been formed in the box. The index table moves the box into the oven for final curing. The core box halves are separated when the index table rotates to the discharge station. *Pat. No. 2,832,107, Harrison Weaver, Jr., assignor to Brillion Iron Works, Inc.*

Shell core blower — 2

■ Another development of a shell core blower includes electric heating elements which heat the core box halves directly, thus eliminating the transfer of the core



box to a separate oven. In the operation of this machine, air pressure is applied to the resin-sand mixture in the hopper (111) and the mixture is then forced into the core box (115 and 105). A

Continued on page 21

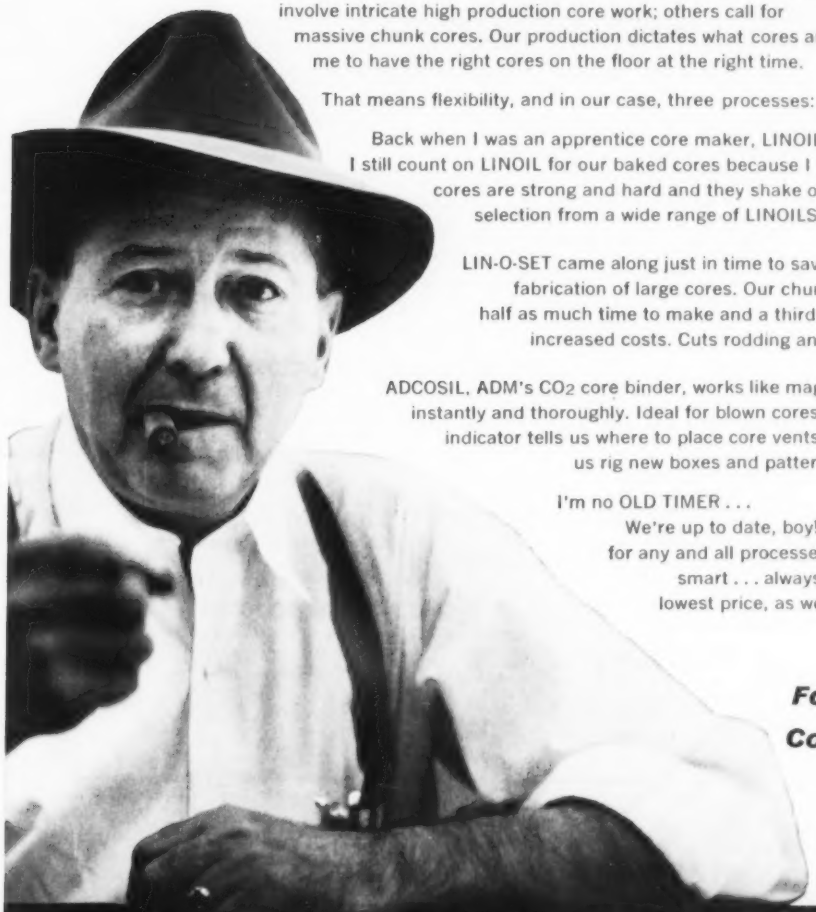
Sure, I've been running this core room since you were in knee britches. But my boss doesn't hire whiskers; he wants performance — the right cores for the job. And the work here varies all over the lot. I stay right up to date on binders, processes and brands, so —

don't call me an

OLD TIMER!

We're using all three, aren't we?

LINOIL...for oil-sand cores
LIN-O-SET...for air setting
ADCOSIL...for CO_2 gas curing



This is a jobbing foundry. We sell custom castings at a profit — some involve intricate high production core work; others call for massive chunk cores. Our production dictates what cores are needed, and it's up to me to have the right cores on the floor at the right time.

That means flexibility, and in our case, three processes: conventional, air setting, and CO_2.

Back when I was an apprentice core maker, LINOIL was the oil we depended on. I still count on LINOIL for our baked cores because I get consistent quality and uniformity – cores are strong and hard and they shake out like sugar. I can make a selection from a wide range of LINOILS for any type job.

LIN-O-SET came along just in time to save us time and money in the fabrication of large cores. Our chunk cores now take half as much time to make and a third less time to bake. Helps offset increased costs. Cuts rodding and cleaning in half, too!

ADCOSIL, ADM's CO_2 core binder, works like magic to cure intricate cores instantly and thoroughly. Ideal for blown cores. ADCOSIL with color indicator tells us where to place core vents and helps us rig new boxes and patterns.

I'm no OLD TIMER . . .
We're up to date, boy! We buy ADM-Federal core binders for any and all processes! What's more, we buy smart . . . always order mixed truckloads and get lowest price, as well as reducing our freight costs.

For Scientific Coremaking, I like –

Archer QUALITY

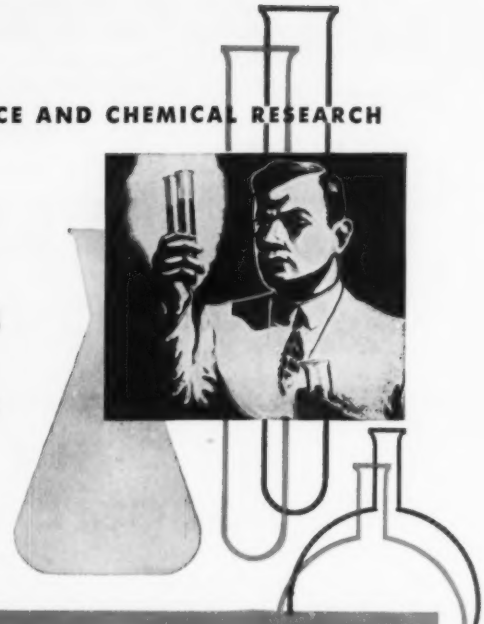
Archer Daniels Midland company

FEDERAL FOUNDRY SUPPLY DIVISION

2191 West 110th Street · Cleveland 2, Ohio

Circle No. 491, Page 151-152

TEAMWORK . . . IN FOUNDRY SCIENCE AND CHEMICAL RESEARCH



DELTA FOUNDRY PRODUCTS

for faster production of FINER FINISH CASTINGS at lower cost

For more than a quarter of a century Delta Oil Products Corp. has pioneered in the development of plastic-type core and mold washes and has continued to lead in the introduction of new and improved products for the production of better castings — faster and more economically.

CORE AND MOLD WASHES:

FOR GRAY IRON, MALLEABLE & NON-FERROUS:

PLASTIC TYPE
- *Regular Base
- *Special Base
- *Z-Special Base
- *BlacKoat C-2
- *BlacKoat C-4
- *BlacKoat S-5
- *GraKoat
- *PyroKoat-G
- *PyroKoat-S RedKoat
- *ShellKoat FM
- *SteelKoat
- *SuperKoat
- *ThermoKoat
- *Z-Koat
- *ZZ-Koat

POWDER TYPE
- DriKoat F
- DriKoat B-3
- DriKoat B-5
- DriKoat B-10
- DriKoat B-15
- DriKoat Z
- DriKoat ZZ
- PyroKoat

LIQUID TYPE
- *SuperKoat

FOR STEEL:

PLASTIC TYPE
- *Regular Base
- *Special Base
- *Z-Special Base
- *PyroKoat-S RedKoat
- *ShellKoat FM
- *SteelKoat
- *SuperKoat
- *ThermoKoat
- *Z-Koat
- *ZZ-Koat

POWDER TYPE
- DriKoat Z
- DriKoat ZZ
- PyroKoat

LIQUID TYPE
- *SuperKoat

FOR GRAY IRON ONLY:

PLASTIC TYPE
- *ChillKoat

FOR NON-FERROUS ONLY:

PLASTIC TYPE
- *GraKoat A-1
- *NonferrusKoat

A FOUNDRY FIRST . . . BY DELTA

PARTINGS:

LIQUID TYPE
- *Graph-Plate
- Part-Rite
- Regular

POWDER TYPE
- *Partex
- *Super Partex

CONCENTRATE–LIQUID

SPECIFICATION CORE OILS:

with required tensile strength, baking, or drying time, rate of collapsibility, etc.

CORE RESINS:

*LIQUID TYPE–FAST-DRI

CORE BINDERS:

LIQUID TYPE–ROSIN CONTENT

DRY POWDER TYPE
- Dri-Bond
- *Bondite

SILICATE–COLD PROCESS BINDERS:

LIQUID TYPE

DUAL SET–LIQUID
- Mona-Set
- L. V.

SPRAY BINDERS–MOLD:

CONCENTRATE

LIQUID TYPES

MUDDING & PATCHING COMPOUNDS:

PLASTIC TYPE
- *Ebony
- *Sliktite

SPECIALTY PRODUCTS:

- 298XXA CO_2 Release Agent
- *436-B Chill Oil
- Core Rod Dip Oil
- *Sand Conditioning Oil
- *96B Sand Release Agent
- 275B High Temperature Lubricant
- Mold Seal Compounds
- 286XX Sealer Compound
- Liquid Griptite
- 200-3X Core Adhesive
- Griptite Core Paste
- *No-Vein Compound
- *Permi-Bond
- 250XX Ingot MoldKoat
- Hi Temperature Ingot MoldKoat
- Thermofiller

DELTA . . . GOOD TO THE CORE!

Get the facts . . . Working samples and complete literature on Delta Foundry Products will be sent to you on request for test purposes in your own foundry.

DELTA OIL PRODUCTS CORP.
MANUFACTURERS OF SCIENTIFICALLY CONTROLLED FOUNDRY PRODUCTS

MILWAUKEE 9, WISCONSIN

Circle No. 492, Page 151-152

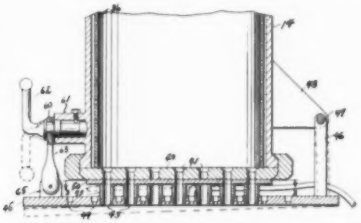
Patent Review

Continued from page 18

hand crank is provided to rock the entire machine as the core is blown. This rocking facilitates the flow of sand into crevices of the pattern. The patent covers a variation of the machine in which the hand crank is used to rotate the machine 180 deg to allow the sand-resin mixture to fall into the corebox by gravity. No air pressure is supplied to the sand hopper in this design. *Pat. No. 2,852,818, Frank Shallenberger and Loren D. Millard, assignors to Shalco Engineering Corp.*

Core blower

■ A core blower with a feature which claims to provide an efficient means of accommodating various types of core boxes with different job requirements has been patented. In this machine, the perforated vent plate (45) is hinged so that it may be dropped away from the



perforated blow plate (40) through which sand enters the core box from the sand hopper (14).

When the vent plate has been dropped, a masking plate (50) may be inserted between the vent and blow plates. A masking plate is provided for each core box and it determines which holes in the blow plate will be connected to holes in the vent plate. Thus the masking plate allows sand to be directed into particular areas of the core box. *Pat. No. 2,839,798, Hans G. Hinrichs, assignor, by mesne assignments, to Archer-Daniels-Midland Co.*

Cores for investment casting

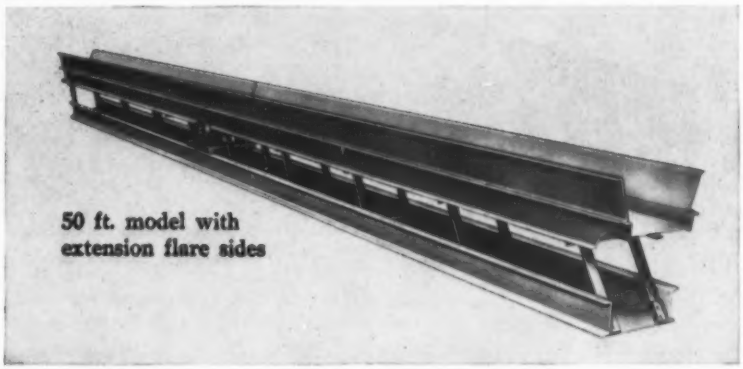
■ Smooth passages in investment cast manifolds may be produced with refractory cores cast in transparent plastic tubing. The patented procedure utilizes commercially available extruded tubing (8 and 9) and cast or extruded fittings

(10, 11 and 12 which may be cemented together to form a shell which is filled with a refractory core forming material. The shell may be reused if it is made as two halves. If the shell is not to be reused it may be removed from the core by burning, cutting, stripping or chemical action. *Pat. No. 2,834,077, Howard A. Greis and John R. Watson.*

SYNTRON **Counter Balanced**

Motor Driven

Vibrating Conveyors



50 ft. model with extension flare sides

handle hot abrasive ores, shake out sand, and rough castings at high rates

SYNTRON Counter Balanced Vibrating Conveyors are versatile and economical with many industrial applications—with modifications they may be used for high speed conveying, screening, drying, cooling, etc.

They are motor driven units consisting of two equal length troughs independently mounted on a common base. One eccenter and drive rod operates each section providing a powerful, gentle vibrating action that moves large volumes of material in a uniform, continuous flow.

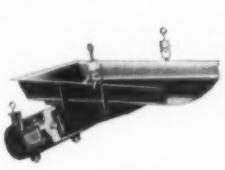
All metal construction, fewer working parts mean dependability and longer life with a minimum of maintenance.

SYNTRON Counter Balanced Vibrating Conveyors are available in lengths and widths to meet most requirements. Installation is easy. Low operating and maintenance expense keep materials handling cost down.

Write for free informative literature

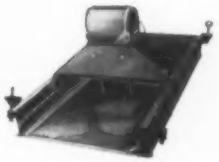
SYNTRON COMPANY
545 Lexington Avenue — Homer City, Penna.

Other SYNTRON Equipment of proven dependable Quality



VIBRATORY FEEDERS

BIN VIBRATORS



VIBRATING SCREENS

DRY FEEDER MACHINES

VIBRATING CONVEYOR SCREENS

Circle No. 493, Page 151-152

let's get personal

B. D. Claffey . . . general manager of GHR division of Dayton Malleable Iron Co., Dayton, Ohio, was named a vice-president of the company. He was an AFS national Director, 1940-43.

V. C. Reid . . . has been elected president of City Pattern Foundry & Machine Co., Detroit, Mich. Reid has been with the company since 1934. He is a past chairman of AFS Detroit Chapter and a past national director of the Non-Ferrous Founders' Society. **Edward Eikamo** has been appointed comptroller. **H. S. Ball** will continue his position as sales director.

C. A. Anderson . . . has been appointed as assistant general manager, Bay City Foundry Co., Bay City, Mich.

A. C. Buesing . . . has been named vice-president of Brown Thermal Development Co., Elyria, Ohio. Buesing was formerly with the Gray Iron

A. C. Buesing

Research Institute of Columbus, Ohio and Modern Equipment Co., Port Washington, Wis. He is a member, AFS Northeastern Ohio Chapter.

C. S. Anderson . . . has been elected board chairman, president and director, for the ensuing year by stockholders and directors of Belle City Malleable Iron Co., and Racine Steel Castings Co., its wholly owned subsidiary, Racine, Wis. Other directors and officers elected: **R. J. Swartout,** vice-president, assistant secretary and director; **B. H. Regenburg,** vice-president, treasurer, secretary and director; **R. R. Roberts, W. H. Bemis, A. J. Stilwell** and **W. C. Cummins,** directors. Anderson observed his forty-fifth year of service with the firm and has been president since 1935.

G. C. Curry . . . has been appointed vice-president in charge of sales, Dollin Corp., Irvington, N. J. He is vice-president of American Die Casting Institute and a member of the American Ordnance Association.

S. W. Gearhart, Jr. . . . has been promoted to chief metallurgist at Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa. **R. W. Brown** has been appointed railway and industrial sales engineer and will represent the firm in sale of railroad specialties and industrial castings in Baltimore, Md., Philadelphia, and the eastern United States.

B. E. Shirley . . . is the new resident salesman for the San Diego area of Electric Steel Foundry Co., Portland, Ore. He will serve the San Diego aircraft, missile and other industries with wrought forms of the aircraft and commercial grades of stainless steel, as well as the cast forms of stainless, titanium, zirconium, magnesium and aluminum.

T. H. Iveson . . . has accepted the position of managing director of Vickers Hoskins Pty, Ltd., Bassendean, W. Australia.

Herbert Hoover, formerly of Strong Steel Foundry Co., Buffalo, N.Y., has joined Buffalo Forge Co. as foundry foreman.

Fred Dischinger . . . has accepted the appointment as plant manager of Kolcast Industries, Minerva, Ohio, plant. He joined the firm in 1954 as chief engineer, a position he held until the present appointment. **H. D. Blake** is the new chief engineer for Kolcast. His previous position was supervisor of engineering.

M. L. Slawsky . . . metallurgist supervisor, Watervliet Arsenal, has been appointed consultant to the Heat Treating Committee of Investment Castings Institute, metals division, Chicago.

E. Veselik . . . has been elected president, Calumet Steel Castings Corp., Hammond, Ind. Other newly elected officers and directors are: **C. J. Masepohl,** vice-president; **W. F. Jicha,** treasurer; **C. K. Garrison,** secretary; **R. J. Pennington,** assistant secretary and treasurer.

J. L. Goheen . . . has been named assistant manager of the Los Angeles office, Climax Molybdenum Co., Div., American Metal Climax, Inc. In his new position he will service firm's West Coast foundry customers. **W. F. Craig, Jr.** is the new manager of metallurgical development and will head a staff of engineers providing developmental assistance and technical services to producers, designers and fabricators of iron, steel and other metals containing molybdenum. Climax Molybdenum has appointed **N. L. Deubel,** manager of the Metallic Molybdenum Development and Service Div., as a senior metallurgical engineer to head an expanded metallic molybdenum development and task force.

A. Brent Wilson . . . was appointed executive vice-president of Harbison-Pa. **A. L. Garber** will remain as Walker Refractories Co., Pittsburgh, president and chief executive officer will also perform the duties of pres- and will be assisted by Wilson who ident in Garber's absence.

R. V. Simpson . . . has joined Birdsboro Steel Foundry & Co., Birdsboro, Pa., as railway and industrial sales engineer.

R. W. Cummings . . . was elected treasurer of Crouse-Hinds Co., Syracuse, N.Y. He succeeds **J. R. Tuttle,** who will continue as chairman of the board of directors.

A. V. Carlson . . . has been promoted from foundry consultant to plant engineer at T. B. Wood's Sons Co., Chambersburg, Pa. He is a member, AFS Chesapeake Chapter.

Continued on page 138

Circle No. 494, Page 151-152

Silicon, a single element essential in cast iron, is available to the foundry trade in many varied ferro alloys. No single ferrosilicon is right for all melting conditions and irons. Rather, specific alloys have been developed which are tailored to provide maximum economy and effectiveness for specific applications.

Our brochure, "Silicon in Cast Iron" discusses the function of silicon in iron and will serve as a guide to the selection of the proper grade of ferrosilicon for your cupola or ladle needs.

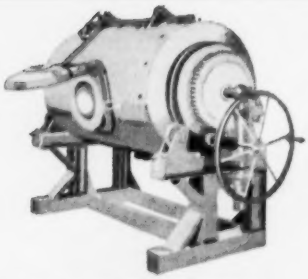
Write for your copy or contact our nearest sales office.

QUALITY · DEPENDABILITY · SERVICE

Ohio Ferro-Alloys Corporation
Canton, Ohio

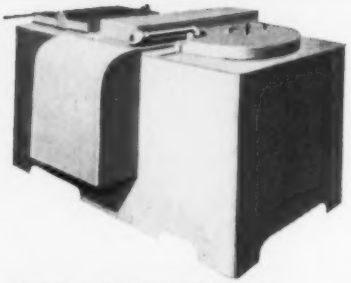
DISTRICT SALES OFFICES: BIRMINGHAM, CHICAGO, DENVER, DETROIT, HOUSTON, LOS ANGELES, MINNEAPOLIS, PHILADELPHIA, PITTSBURGH, SAN FRANCISCO, SEATTLE

Wherever industry needs heat... There's LINDBERG equipment just right for the specific job

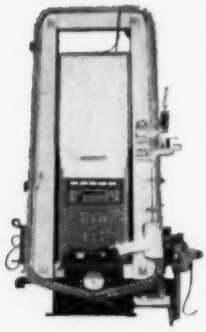


Rotary Open-Flame Smelting Furnaces: Lindberg-Fisher Simplex (shown) either oil or gas fired with capacities to 30,000 lbs. brass, 2,400 lbs. aluminum.

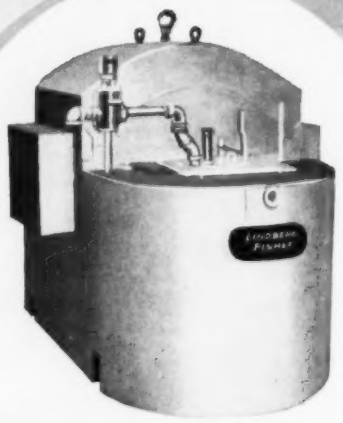
Automatic Ladling Units: The Autoladle "Little Joe". The first practical automatic aluminum ladling unit yet devised.



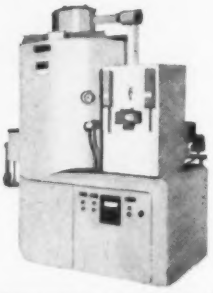
Induction Melting and Holding Furnaces: Lindberg-Fisher two-chamber furnace (shown) melts in one chamber, holds at correct temperature in other.



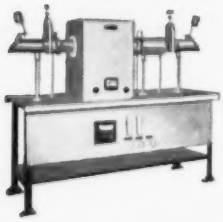
High Frequency Units: Vertically designed, completely automatic "HF" unit (Shown) for aluminizing automotive valves.



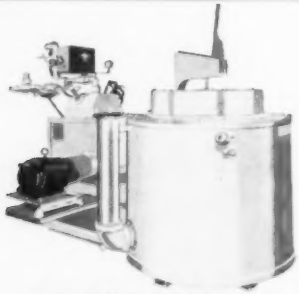
Melting and Holding Furnaces: Electric resistance furnace (shown) with capacities of 750 lbs. to 1500 lbs.



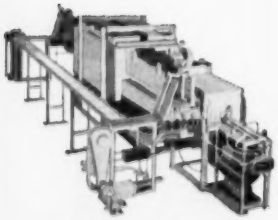
Atmosphere Generators: Hyen generator (shown) for endothermic atmospheres. Generators for all required atmospheres.



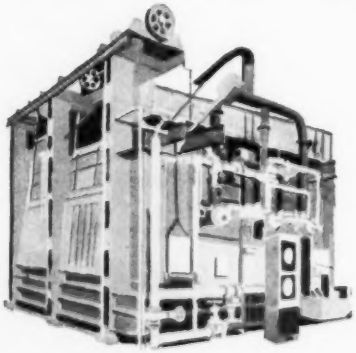
Pilot Plant Equipment: Atmosphere tube unit (shown) for ceramic research and development at temperatures up to 2750° F.



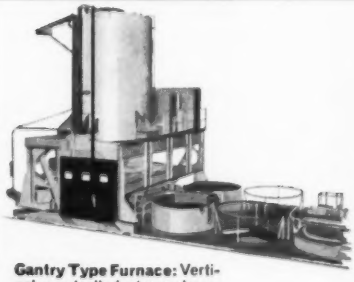
Cyclone Tempering Furnaces: Batch type fuel-fired tempering furnace (shown). Famous in metal treating industry for years.



Ceramic Kilns: Fully automatic, atmosphere controlled kiln (shown) has 5 control zones for flexibility. Maximum temperature, 2700° F.



Aluminum Reverberatory Furnaces: Twin-chamber melting and holding furnace (shown) with 45,000 lbs. capacity.



Gantry Type Furnace: Vertical, controlled-atmosphere, drop bottom, hardening furnace. Complete installation field-installed by Lindberg.

Circle No. 495, Page 151-152

Lindberg-Designed

furnaces, more than 75 of them, help Ford Motor Company maintain casting production and quality standards

The new Aluminum Castings Plant of Ford Motor Company, Engine and Foundry Division, at Sheffield, Alabama, is a model of modern production efficiency. Contributing to its effective operation is a huge battery of Lindberg-Fisher aluminum holding furnaces, more than 75 of them. Eight large 65,000 lb. capacity reverberatory holding furnaces receive molten aluminum delivered from an adjacent Reynolds Metals plant and hold it at the desired temperature. Six other reverberatory furnaces, each with 20,000 lb. capacity, are used for remelting scrap aluminum from trimmed parts and holding metal at its usable temperatures. Molten metal is then delivered to more than 60 electric resistance holding furnaces in the casting area as needed. This unique installation, developed by Ford engineers in conjunction with Lindberg, is a major factor in maintaining the high quality product and production standards required by Ford.

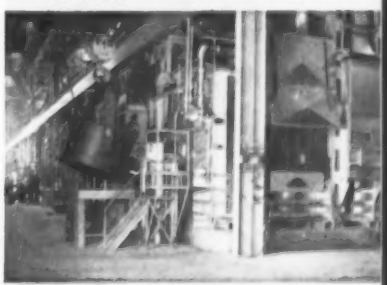
Lindberg equipment and Lindberg planning can help you find the most effective answer to any problem of applying heat to industry. We cover the field, melting and holding, heat treating, tempering, brazing, enameling furnaces, ceramic kilns, high frequency units, and are in the ideal position to recommend just the type of equipment most suitable for your needs. This can be factory built or field-installed in your own plant, fuel-fired or electric. Consult your local Lindberg Field Representative (see the classified phone book) or get in touch with us direct. Lindberg-Fisher Division, Lindberg Engineering Company, 2440 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California.

Handsome entrance to new plant of Ford Motor Company, Sheffield, Alabama.

Metal temperatures are positively controlled through Lindberg Control Panel.

Some furnaces are arranged for hand ladling and others are equipped with Lindberg Auto-ladle.

Molten aluminum is delivered direct to reverberatory holding furnaces.



The molten metal is held in these 14 huge furnaces for distribution to the casting areas.

LINDBERG heat for industry

Circle No. 495, Page 151-152

On the pouring floor of the No. 2 Foundry Unit at Sparta, twenty conveyor lines are poured by 3 ladles

At Sparta Foundry—1 million piston rings a day prove the quality of HANNA PIG IRON

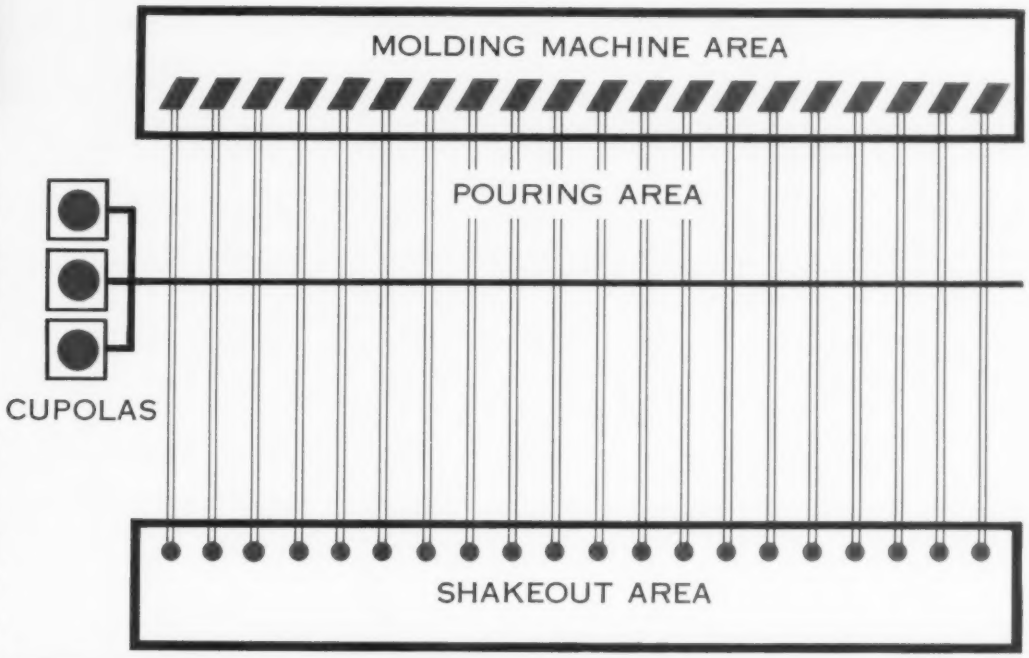
Sparta Foundry Company, a division of Muskegon Piston Ring Company, in Sparta, Michigan, can cast up to 1,000,000 piston rings in a single day. Since 1926, it has produced over three billion rings. In castings for piston rings, which will be ground to a close tolerance, Sparta Foundry demands a strong, fine-grained iron with uniform microstructure. For pig iron sure to produce this quality, Sparta Foundry has relied on Hanna for more than 30 years.

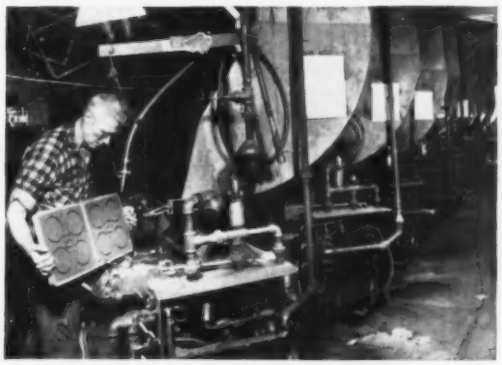
Hanna makes all regular grades of pig iron, plus HannaTite and Hanna Silvery. All are available in two sizes—the 38-pound pig and the smaller HannaTen ingot. Your Hanna representative will be glad to tell you more about the advantages of using Hanna pig iron.

Circle No. 496, Page 151-152

Sparta's operation accents both quality and quantity

This flow chart shows the multiplicity of Sparta's continuous production lines. Twenty molding machines, twenty continuous conveyors, and multiple shakeout stations are part of the operation.





1. *Sparta's No. 2 battery of 20 molding machines. From here, conveyors carry the completed molds to the pouring floor.*

2. *From pouring floor, conveyors take castings to shakeout. After shakeout, piston rings are removed from the "tree."*

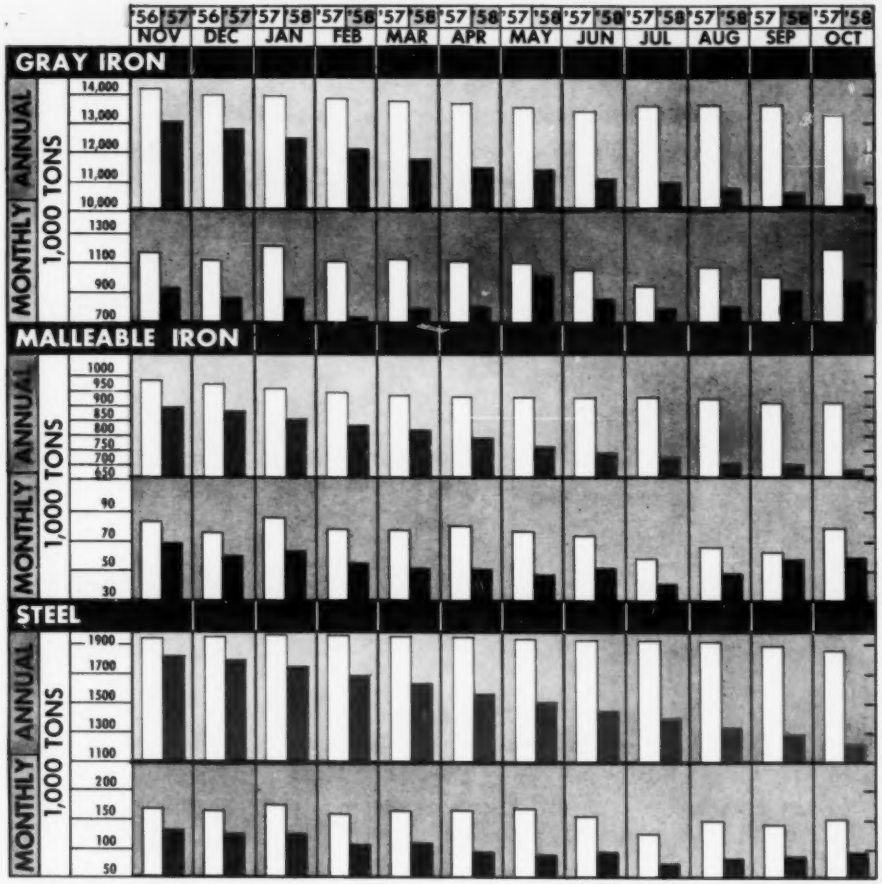
THE HANNA FURNACE CORPORATION
Buffalo • Detroit • New York • Philadelphia
Merchant Pig Iron Division of
NATIONAL STEEL CORPORATION

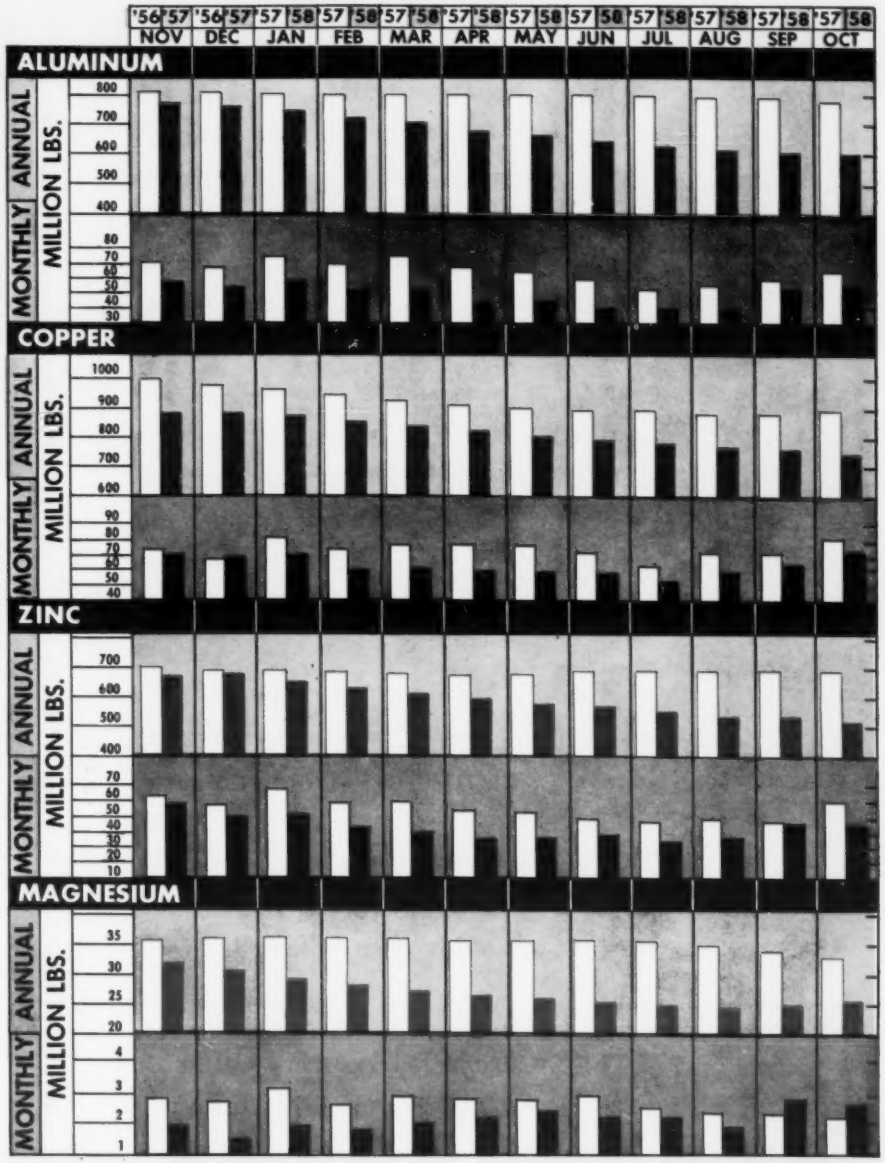
3. *Uniformity and quality are carefully checked in the Sparta laboratories with instruments like this latest Metallograph.*

Circle No. 496, Page 151-152

how's business . . .

The short and long term trend for metalcastings shipments are presented here in bar chart form from statistics provided by the Bureau of Census, Department of Commerce. By examining the upper chart for each metal, you can see how the weight of castings shipped during a 12 month period has gradually declined since the period Dec. '55 — Nov. '56 (first bar left of each chart). A reversal of this long range trend is leveling off as the result of a rebound from the low level of summer months activity. Compared with September, October shipments were officially higher for all metals except zinc and magnesium which dropped slightly.





Each bar in upper chart for each metal represents total shipments for 12 month period ending in year and month indicated. Example: In gray iron chart, last colored bar on right shows 10,300,000 tons shipped during period Nov. '57-Oct. '58 inclusive; adjacent white bar shows 13,100,000 tons for period year earlier, Nov. '56-Oct. '57.

Lower chart for each metal shows total shipments for each month in year indicated. Example: In gray iron chart, last black bar on right shows 990,007 tons shipped in Oct. '58 compared with white bar showing 1,100,000 tons in Oct. '57.

American Brake Shoe . . .

Castings Do It Better For Aircraft Industry

Aluminum alloy foundry at Mahwah, N.J., produces air craft and missile castings that exceed federal specifications

Since there was a growing demand for higher strength and integrity aluminum castings especially in the aircraft and missile industries, American Brake Shoe Co. undertook a research program to develop techniques to produce such parts. A successful small-scale operation was carried on at their research center in Mahwah, N. J. which led to their present aluminum alloy foundry. One of the principal products at their new Mahwah plant is high strength aluminum castings.

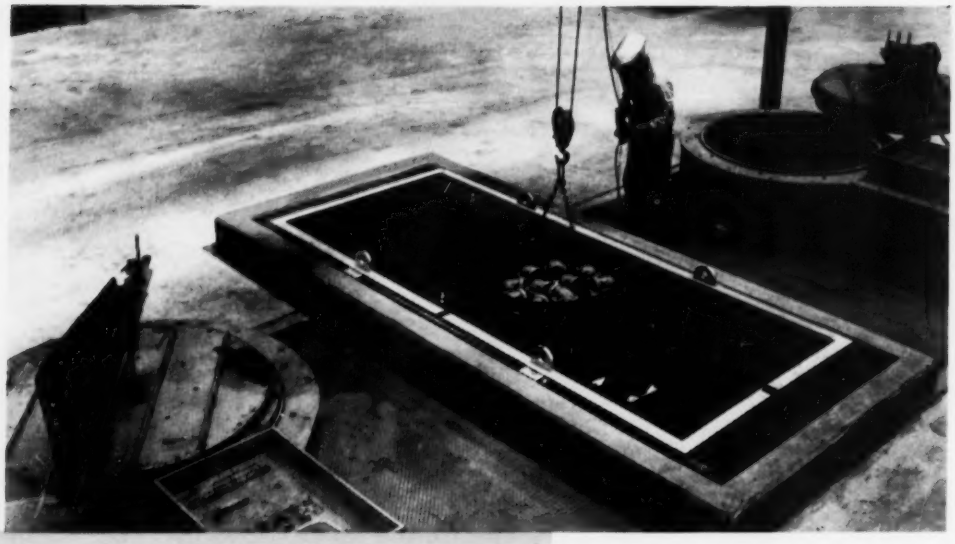
The opening of the Mahwah plant in July, 1957, was the outgrowth of research and development that was begun in 1952 at the Frankford Arsenal and continued later at the Massachusetts Institute of Technology. From this work, recommendations were made that Brake Shoe undertake research into the properties of aluminum castings because of their great potential. In the next three years of research at the company's Mahwah laboratory aluminum sand casting techniques were developed capable of producing castings with much higher standards than those established in federal specifications.

A check of various markets, especially aircraft, disclosed that demands for high strength aluminum castings were rapidly growing. Brake Shoe then cooperated with Grumman Aircraft on a test program. Twelve promising aircraft components were selected for trial casting. Of the 5000 castings eventually produced by Brake Shoe in this pilot plant operation, Grumman rejected less than one per cent. Heretofore, Grumman had been rejecting castings at the rate of 35 per cent. These highly satisfactory results encouraged Brake Shoe to build the modern aluminum foundry described in this article. The foundry is currently producing aluminum alloy parts which include aileron control sections, bell cranks, rudder control supports, fuselage fittings, bulkheads, fuel elbows, elevon hinge fittings and other structural parts.

Exceeding Specifications

These castings are being produced primarily in two high strength grades of type 356 aluminum alloy. One grade, designated 356-S has, in high stress areas, a minimum tensile strength of 42,000 psi, a minimum yield strength of 35,000 psi and an elongation of 3 per cent. In less critical areas minimum physicals are: 36,000 psi tensile strength, 32,000 psi yield strength and 2 per cent elongation. Low iron content of the aluminum is an important factor contributing to improvement in physicals.

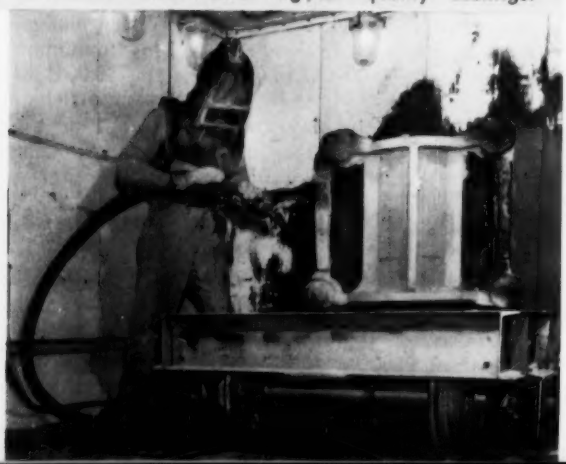
Brake Shoe's class 356-T castings meet the following minimums in critical areas: 38,000 psi tensile strength, 28,000 psi yield strength and an elongation of 6 per cent. In



Improved methods for heat treating help produce top quality castings.

Core production and assembly line leads into dielectric core oven.

Cleaning operation is done manually to insure highest quality castings.



other areas minimums established are: tensile strength, 33,000 psi; yield strength, 27,000 psi; elongation, three per cent.

Brake Shoe also stresses the importance of determining casting properties on test coupons cut from the casting itself. Federal specifications, on the other hand, have two sets of requirements—one on test bars that are cast separately and another on an average from the castings themselves.

According to federal specifications, separately cast test bars should conform with these minimums: tensile strength, 30,000 psi; yield strength, 20,000 psi; elongation, 3.0 per cent. Properties in the actual castings need only average 22,500 psi ultimate, 15,000 psi yield and 0.75 per cent elongation. Of course, an average will include areas which have mechanical properties that fall below the average.

Quality Control

Brake Shoe stresses that its production of high integrity aluminum castings does not depend on the possession of patents. Instead the emphasis at the Mahwah plant is on rigorous adherence to careful controls throughout foundry operations.

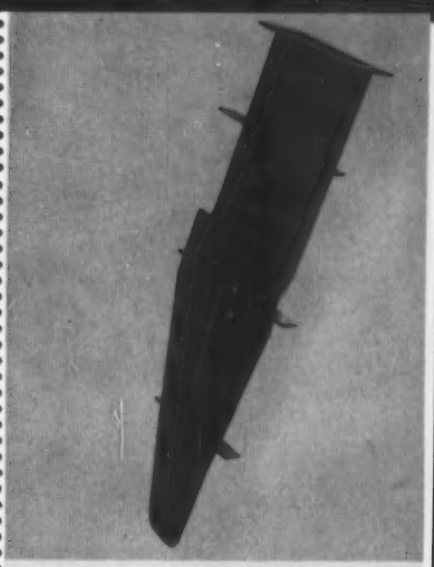
Careful controls begin with the use of high purity virgin melting stock. Efficient melting practices require scrupulous care in degassing which is accomplished by flushing with nitrogen. Temperatures are checked constantly during the degassing operation. The extent of degassing is determined by solidifying a sample from the melt under vacuum. A cross-section of the solidified sample is then examined for porosity and microshrinkage. This method was instituted because it is a fast, reliable indicator of melt quality.

In producing high standard aluminum castings, Brake Shoe also employs improved methods in mold preparation, pouring, use of risers, cleaning and heat treatment.

The pouring procedure is designed to minimize

Fuel elbow for McDonnell Aircraft.

Checking dimensions on fixture.



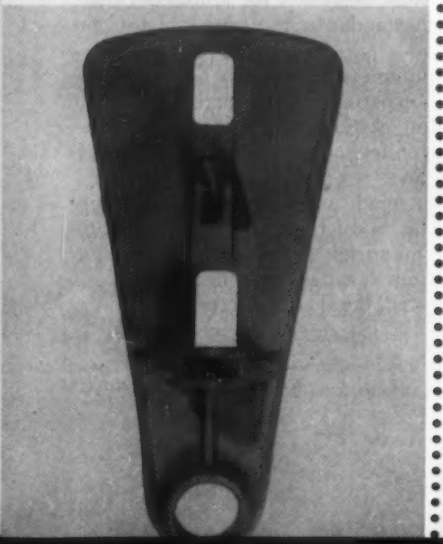
Missile airscoop for Glenn L. Martin.

Grumman control fitting castings.

Fluorescent particle inspection.

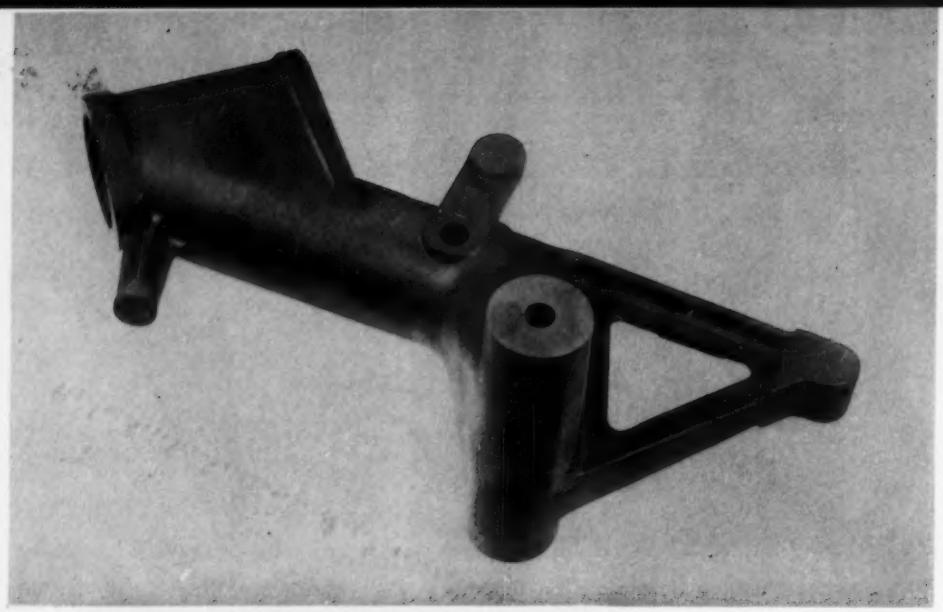
Grumman Aircraft control castings.

Bulkhead with ⅛-in. wall for Cessna.



X-ray inspection of castings.

Gimbal for missile guidance system.



Control column fitting produced for Grumman.

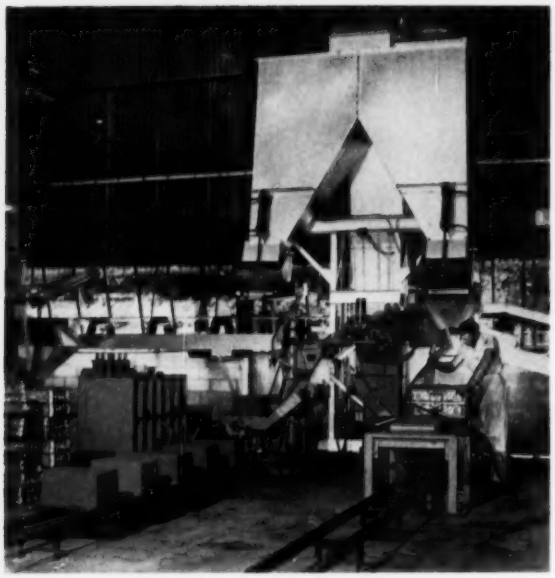
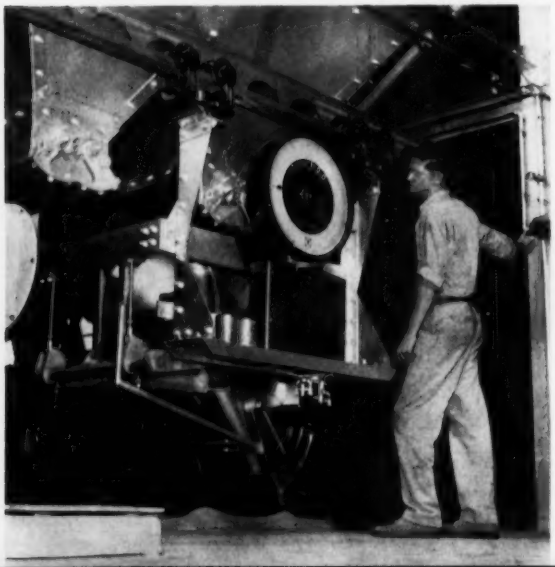


Table automatically places rammed flask and board on track conveyor.

Operator weighs all sand that goes into Brake Shoe molding mixtures.



melt agitation. Cores and chills are set by hand. Cleaning is also done manually. Hand operations insure a higher quality finished casting. Constant inspection of the castings at various stations during the production process characterizes the foundry.

Casting Advantages

The advantages of using high strength aluminum castings produced by modern foundry technology include:

1. **Designers can reduce weight requirements.**
2. **Greater strength and wider safety margin possible.**
3. **Strength-weight ratios are increased.**
4. **Consistent, uniform qualities in high strength and soundness are achieved in castings.**
5. **Rejection percentages are smaller.**

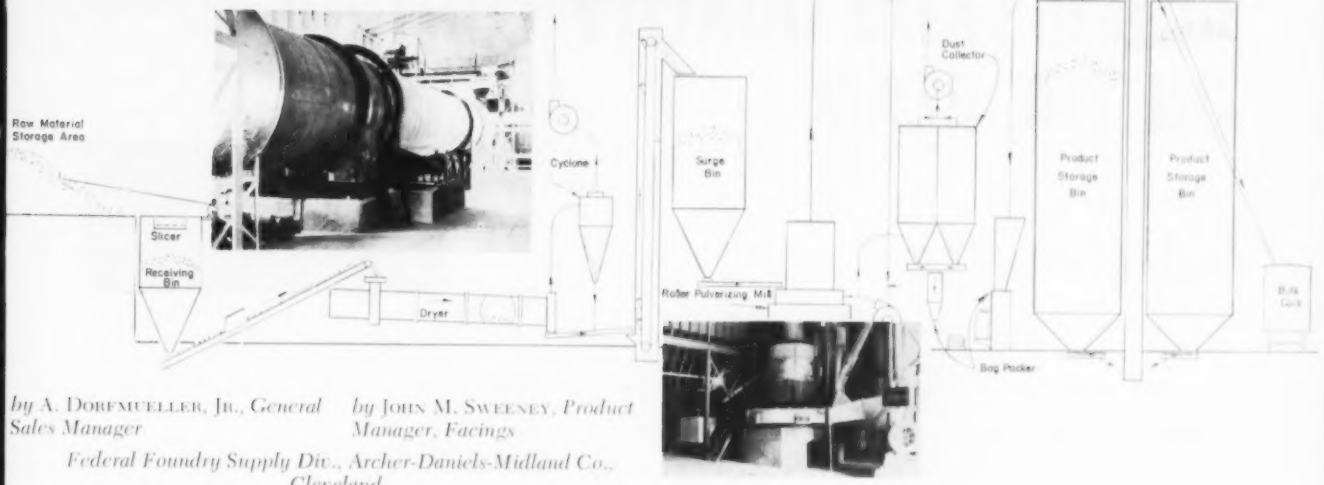
Currently, Brake Shoe is manufacturing castings for use by the military aircraft industry. Weights range from several ounces to 500 lb. With the increasing demand by aircraft designers for aluminum castings that meet high standards, the potential for the product should grow.

Because the aluminum alloy foundry is such a recent outgrowth of experimental research, the Mahwah plant is getting casting jobs that require considerable pioneering in technology.

Certainly Brake Shoe is doing its part to carry out the recommendation made in 1956 by the Materials Advisory Board. This body then urged that the aircraft industry and foundries cooperate in raising the standards of aluminum castings. Only in this way can their use be accelerated, the Board asserted.

KNOW YOUR FOUNDRY MATERIALS

The Birth of Bentonite



by A. Dorfmueller, Jr., *General Sales Manager*

by John M. Sweeney, *Product Manager, Facings*

Federal Foundry Supply Div., Archer-Daniels-Midland Co., Cleveland.

Most foundrymen never see bentonite sand binder until it arrives at the plant neatly packaged in paper sacks. Ever wonder where it came from . . . how it occurs in nature . . . what processing it requires? These questions will be answered by climbing aboard this magic carpet of printer's ink for a tour of the bentonite mining operation and new processing plant recently built by Federal Foundry Supply Div., Archer-Daniels-Midland Co.

Your visit will bring you to one of the most beautiful areas in the state of Wyoming, where the plant is located on 100 acres of land. In the immediate vicinity over a million tons of high-grade virgin clay are available. An additional 150,000 tons are stockpiled at the plant site.

The mining and processing of bentonite is much more than just digging clay out of the ground and grinding it. Since bentonite deposits vary in individual characteristics, each deposit is test drilled and plotted on contour maps.

Selective mining is then done by removing the overburden with scrapers and the clay removed on a selective basis by power shovels and crawler tractors. This clay is then stock-piled as to grade—high gel and low gel.

The processing operations are housed in a building 300 ft long, 50 ft wide and 50 ft high. Crude clay is bulldozed from the stock pile directly into the crude shed, capable of storing 1000 to 1500 tons.

From the crude shed the material is scooped to the slicer by a three-drum control slusher. The crude material feeds through a rotary knife slicer which reduces the crude clay to manageable size (golf ball size or smaller) and drops it into a receiving bin with a 100-ton capacity located directly below it.

From the receiving bin the sliced material moves by belt conveyor into the drier. As the moisture in the bentonite varies, the speed of the feed conveyor rather than the heat of the drier changes to compensate. The drier handles a maximum of 20 tons per hour of clay.

The drying operation is fully automatic. The sliced clay entering the drier ranges from 24 per cent to 28 per cent moisture and leaves with approximately 10 per cent moisture.

The sliced and dried bentonite is conveyed to a 150-ton capacity storage bin. Screw conveyors, located on the underside of storage bin, feed material into the mill.

The mill is one of the largest roller pulverizing mills in use. Mill is 66 in. in diameter, has five rolls with a 9-in. bull-ring. Its approximate capacity is 25 tons of material per hour.

Above the mill a mechanical separator is driven by a 15 hp motor through a variable speed drive. The speed of the separator determines the fineness of the material taken from the mill. Ground material is air-conveyed from the mill to a cyclone separator where the material is dropped through an automatic air lock into a screw conveyor. From here bentonite goes to either of two 500-ton storage silos. Or it can flow directly into railroad cars. Individual screw conveyors under each silo feed load-out elevators which deliver to either of two packer bins for bagging. Spout air flow packers fill 400 to 500 bags per hour. As the bags are packed they are automatically weighed and then conveyed directly into boxcars for hand loading or to a palletizing station.

On the plant site is a combination laboratory, office and welfare building. The welfare section of the building contains lockers, showers and dining facilities. The laboratory and office sections are combined. The laboratory is staffed by a plant chemist and contains every practical piece of laboratory equipment necessary to enable supervision to make immediate accurate decisions on quality control.

Bentonite is much more than just ground clay. It is a scientifically mined and processed clay that has wide ranges of application in our foundry trade and also in oil-well drilling, paints, cosmetics, tooth paste, paper, foods, detergents and the processing of iron ore, to mention but a few. ■ ■ ■

HOW TO KEEP GREEN SAND QUALITY CONTROL ON THE BEAM

This article received first prize in the 1958 Annual Paper Writing Contest sponsored by the Ontario Chapter of the American Foundrymen's Society.

A. JOHNSON/
American Standard Products (Canada) Ltd.
Toronto

Green sand for molding can be controlled for consistent performance once you recognize the inter-relationships of the various physical properties with the moisture and clay content. If one physical property of the sand is out of control, the sand may still be in control because of balancing effects of another property. This article tells how to correlate these properties to serve as a guide in keeping molding sand mixtures "on-the-beam" for quality control.

MOISTURE

The control of moisture in molding sand is the key to good castings. The tightest possible maximum and minimum limits for the percentage of moisture in the sand must be set. Fractions of a per cent can mean the difference between a bad casting and a good one. Varying moisture content can account for changes in casting finish, flowability, green strength and permeability. Increasing the moisture will increase deformation and give a more workable sand. The proper percentage of moisture in the sand is governed by the clay content and the casting to be made. Any major change in clay content should be accompanied by a change in moisture.

CLAY CONTENT

The control of the clay content in molding sand is second only to moisture control. An increase in the clay content will increase the mold hardness and the green compression strength, and decrease the permeability and the flowability. The clay content should be kept high enough so that the molding sand will not produce any sand defects on the casting to be made.

When the sand is tempered to the right feel, and still cuts, washes, rat-tails and scabs persist, an increase in the clay content is usually the answer. On particular jobs that tend to have sand defects an increase in clay content even to the extent of giving a green compression strength of 16 to 18 psi is recommended. The moisture content, however, should not be allowed to climb too high when running a high strength sand.

Table 1 – Effects of Clay Changes on Green Sand Properties

Increasing	Clay	—	Increases green compression strength
"	"	—	Improves casting finish
"	"	—	Increases mold hardness
"	"	—	Decreases permeability
"	"	—	Decreases flowability
"	"	—	Reduces cuts, washes, rat-tails and scabs

Any change in the clay content of the molding sand can be detected by a change in green strength. If a molding sand has a green strength of 10 psi with a moisture content of 2.8 per cent, and then the green strength rises to 12 psi with still 2.8 per cent moisture content, the sand has increased in clay content:

2.8% moisture + 5% clay = 10 psi green strength
2.8% moisture + 6% clay = 12 psi green strength

Even when there is no increase in green strength, a high clay content can still be present. If the moisture and the clay content decrease together, no change in the green compression strength takes place.

2.8% moisture + 5% clay = 10 psi green strength
2.6% moisture + 4% clay = 10 psi green strength

The Case of the Increasing Clay

A molding sand in the foundry has a moisture content of 2.8 per cent and a green compressive strength of 10 psi with 5 per cent clay content. A stronger sand is required for the job, so the clay content is increased to 6 per cent. The resulting green compressive strength is now 12 psi. This mix improves the finish on the casting and the strength is kept at 12 psi.

After operating some time, it is noticed that the moisture content of the molding sand has climbed to 3.0 per cent but the green compression strength has remained at 12 psi. The moisture content is immediately reduced to the 2.8 per cent specified as optimum. But now the green compression strength climbs to 14 psi and the sand feels dry and brittle. So the moisture content is returned to 3.0 per cent, the green compression strength drops to 12 psi and the mix proves satisfactory for the job.

But now the sand is unable to run at 2.8 per cent moisture content as it did previously. Is it possible to get back to the 2.8 per cent moisture content and still have a workable sand? What has happened to the mix that makes it need 3 per cent moisture? If the sand mix is tested for clay it will be found that the clay content has gradually increased to 7 per cent. By bringing the clay content back to 6 per cent the moisture content of the molding sand will automatically decrease, and the sand will have the same feel. The chronology of this experience follows:

2.8% moisture + 5% clay = 10 psi green strength – Too weak
2.8% moisture + 6% clay = 12 psi green strength – OK for job
3.0% moisture + 7% clay = 12 psi green strength – High moisture
2.8% moisture + 7% clay = 14 psi green strength – Too dry and brittle
2.8% moisture + 6% clay = 12 psi green strength – OK for job

The Case of the Deep Draw

A sand is required to make a casting with a deep draw. The molding sand on hand does not have enough deformation to lift out of the pocket. The sand mix has a moisture content of 2.8 per cent and a green compression strength of 10 psi with 5 per cent clay content. The moisture content is raised to 3.0 per cent and the strength drops to 9 psi. The pattern draws clean. But after the casting has been poured, scabs and a rough finish are noticed.

The moisture content is then decreased back to 2.8 per cent and the brittleness of the molding sand is put up with in order to obtain a good finish. What should have been done when the moisture content was increased to 3.0 per cent was to also increase the clay content to 6 per cent, so that the green compression strength would remain the same. The pattern would then be able to draw and a smooth finish would still be obtained. Again any change in clay content should be accompanied by a change in moisture if the same feel is required.

2.8% moisture + 5% clay = 10 psi green strength – Too brittle
3.0% moisture + 5% clay = 9 psi green strength – Scabs and rough finish
3.0% moisture + 6% clay = 10 psi green strength – Good draw and smooth finish.

FLOWABILITY

The flowability test is an important control to determine if the sand is tempered to the correct moisture content. This test is taken by ramming a test specimen to a two-inch height with three rams of a 14-lb. weight. Two more additional rams are taken, and the decrease in specimen height between the fourth and fifth ram is measured on a flowability gauge. This number represents the flowability of the sand. As the number increases the sand is said to be more flowable. A decrease in the number indicates a less flowable sand. This method requires an extra sample to be rammed up for this test. By taking a reading between the second and third ram of a regular test specimen, any change in the flowability can be noticed.

Table 2 – Effects of Moisture Changes on Green Sand Properties

Increasing	Moisture	—	Increases deformation
"	"	—	Improves workability
"	"	—	Decreases green compression strength
"	"	—	Roughens finish
"	"	—	Decreases flowability if sand is tempered too wet
"	"	—	Lowers sand density if near correct temper point
Decreasing	"	—	Makes sand mix brittle
"	"	—	Increases flowability if sand is tempered too dry

On the third ram of a test specimen for a green compression test, if the reading on the flowability meter decreases, the sand is tempered to too high a moisture content. Any increase in the moisture content yields a lower flowability reading.

Effect of Moisture Increase

This is what sometimes happens. A molding sand has a moisture content of 2.8 per cent and a flowability reading of 55 on the third ram. The moisture content increases to 3.0 per cent and the flowability reading drops to 50. Since the flowability reading has dropped, this sand is tempered too heavy.

Now after a period of a week, the flowability reading increases to 55, but the moisture content is 3.0 per cent. The moisture content of this present sand is decreased to 2.8 per cent to bring the moisture back in line. But the flowability reading has increased to 60. So now a flowability reading of 60 is obtained when 55 was the reading last week, with the same moisture content of 2.8 per cent.

The only apparent difference in the two sands is that this week's sand seems drier to the feel than last week's sand. What has happened? *The clay content has increased.*

Solution:

The sand should be tempered to a moisture content of 3.0 per cent to give the same feel and to get back to the 55 flowability reading.

2.8% moisture + 5% clay = 55 flowability reading on the 3d ram – OK for job
3.0% moisture + 5% clay = 50 flowability reading on the 3d ram – Tempered too heavy
3.0% moisture + 6% clay = 55 flowability reading on the 3d ram – OK
2.8% moisture + 6% clay = 60 flowability reading on the 3d ram – Too dry, too flowable
3.0% moisture + 6% clay = 55 flowability reading on the 3d ram – OK

The flowability reading can be a guide to proper tempering. If the moisture content has increased, see

if there is any change in the flowability reading before making any change in the sand. If there is no flowability change, then the higher moisture content is still tempering the sand properly. A decrease in moisture content will only yield a drier, unworkable sand. The proper thing to decrease is the clay content if the moisture content is to be brought back to its original state. However, if the moisture content has increased and the flowability drops, then the sand is definitely tempered too high.

Effect of Moisture Decrease

Again let's start with a sand of 2.8 per cent moisture content and a flowability reading of 55. After a period of time the moisture content of the sand decreases to 2.6 per cent and the flowability reading remains at 55. Both of these sands have the same feel. The moisture content is then raised to 2.8 per cent to try and get back to the original sand moisture. But now the flowability reading drops to 50 when 55 was the reading previously, with the same moisture content of 2.8 per cent. The only apparent difference is that this second sand is heavier to the feel than the first. What has happened? *The clay content has decreased.*

Solution:

The sand should be tempered to 2.6 per cent moisture content to get back to the 55 flowability reading and obtain the same feel.

2.8% moisture + 5% clay = 55 flowability reading on the 3d ram – OK for job
2.6% moisture + 4% clay = 55 flowability reading on the 3d ram – OK for job
2.8% moisture + 4% clay = 50 flowability reading on the 3d ram – Flowability too low
2.6% moisture + 4% clay = 55 flowability reading on the 3d ram – OK
2.8% moisture + 5% clay = 55 flowability reading on the 3d ram – OK

If the moisture content has decreased with no increase in flowability, and the sand does not feel dry, then the sand has been tempered properly. If the moisture content is increased, a heavier sand will result and the flowability reading will decrease. The proper thing to increase is the clay content to bring the sand back to its previous state. However, if the moisture content decreases and the flowability increases, then the sand is positively tempered too dry.

DENSITY

The density test is probably the best for a daily routine indicator of changes on any one screen. A 165-gram sample of molding sand is given three rams with a 14-lb weight. The density of the sand in pounds per cubic foot is then read on the density scale. When the molding sand is very close to the correct temper point, a higher moisture content will yield a lower density reading:

2.8% moisture + 5% clay – 91.5 density, lb per cu ft
3.0% moisture + 5% clay – 91.0 density, lb per cu ft

However, a higher moisture content, with a higher clay content to temper the sand will not yield a changed density reading:

2.8% moisture + 5% clay – 91.5 density, lb per cu ft
3.0% moisture + 6% clay – 91.5 density, lb per cu ft

Similarly, a decrease in the moisture content with no change in the clay content will yield a higher density reading and a drier feeling sand:

2.8% moisture + 5% clay – 91.5 density, lb per cu ft
2.6% moisture + 5% clay – 92.0 density, lb per cu ft

However, a lower moisture content with a decrease in the clay content will yield the same density reading and no change in the feel of the sand can be noticed:

2.8% moisture + 5% clay – 91.5 density, lb per cu ft
2.6% moisture + 4% clay – 91.5 density, lb per cu ft

This relationship only holds true when the moisture content of the molding sand is within ± 0.5 per cent of the correct temper point.

A further increase in moisture to 5.0 per cent will yield a higher density reading.

5.0% moisture + 5% clay – 93.0 density, lb per cu ft

The density of molding sand can be judged even without the specific density test. When a sample of the sand has been weighed for a green compression test there is a prescribed weight of sand required to bring it to a two-in. specimen height on the third ram. If this set weight increases, the density of the sand has increased; and if this weight decreases, the density of the sand has decreased. When the moisture content of a sand correctly tempered has increased, it requires less weight to bring the specimen to the two-inch height.

This fact gives another way of telling if the molding sand has been properly tempered. A sand has a moisture content of 2.8 per cent and requires 160 gr to bring it to a two-in. specimen height. The moisture increases to 3.0 per cent and it now requires 150 gr to bring it to a two-inch specimen height. This decrease in weight shows that the sand is tempered heavy. However, by increasing the clay content with a moisture content of 3.0 per cent, 160 gr are required to bring the specimen to the two-in height. This is the same weight as was used with the 2.8 per cent moisture content sand, and shows that the 3.0 per cent sand is now correctly tempered with the increased clay content.

2.8% moisture + 5% clay = 160 gr for 2-in. height (correctly tempered)
3.0% moisture + 5% clay = 150 gr for 2-in. height (not correctly tempered)
3.0% moisture + 6% clay = 160 gr for 2-in. height (correctly tempered)

SUMMARY

1) Any change in the clay content should be accompanied by a slight change in moisture. Any increase in moisture does not always mean that the sand is tempered too heavy.
2) High strength sands tend to improve the casting finish and require less combustibles.
3) Changes in density can be noticed when a sample is weighed for a green compression test.
4) The flowability and density test can indicate whether the sand has been properly tempered with clay. If the moisture content of the sand is high or low, a check should be made to see if the flowability, density and green strength have changed. If they have not, then the sand is properly tempered at its new moisture content. ■ ■ ■

FOAMED ALUMINUM...

"We Make The World's Most Porous Castings"

Jack R. Kreigh-President
Foamalum Corp., LaSalle, Ill.

With outer skin removed, a piece of foamed aluminum floats higher out of the water than balsa wood.

Material can be cast in intricate shapes; the mold wall forms fairly smooth surface on foamed castings.

Foamed aluminum as light as balsa wood is now being tested by aircraft companies to determine its structural value. Foamalum Corp., La Salle, Ill., developers of this cast material, envisions future use of the product in the marine, aircraft, missile, automotive and construction industries.

Density of the foamed metal, controlled by varying the addition of foaming agents, can range from 12 to 70 pounds per cubic foot. Almost any aluminum alloy can be foamed, but magnesium-aluminum alloys reportedly foam the best.

SMOOTH SURFACED CASTINGS

Foamed aluminum can be cast into comparatively intricate shapes. In the casting process a "skin" of comparatively smooth aluminum is formed where the metal comes into contact with the mold. Cells of foamed aluminum are smaller near the surface of the casting. These cells are more constant in size in the heavier densities. The extreme lightweight product (under 20 pounds per cubic foot) is obtained by removing the heavier skin surface from the casting by cutting or machining.

With skin removed, the foamed metal floats as high out of the water as balsa wood. Because a major portion of the cells or bubbles are closed it does not absorb water. The material may be pressed into various shapes without destroying the cell structure—it merely changes the shape of the cell, with little or no splitting or shattering.

Rigidity is good, but no exact measurements have been conducted as yet. Foamed aluminum also has good malleability. Tensile and compressive strength are nearly proportionate to the weight of the foam. Thus, if ingot aluminum weighs 166 pounds per cubic foot, with a strength of 30,000 psi; a block of foamed aluminum weighing 16.6 pounds has a strength of 70-90 per cent of 3000 psi.

Thermo conductivity of the foamed metal is roughly one-80th that of solid aluminum, when weight is one-fourth that of solid aluminum.

COMPRESSING INCREASES STRENGTH

Tests indicate that as the material is compressed, it gains strength. Preliminary results point to indications that original ingot strength is obtained when only half the original density is reached.

Foamed aluminum may be machined, cut with a band saw, nailed, bolted, glued, screwed into, bent or pressed into shape.

Custom castings are being made in green sand shell molds; also in sheets with 3 × 5-in. cross-section.

Depending on density, alloy and complexity of casting, cost ranges from $1.00 to $2.25 per pound. ■ ■ ■

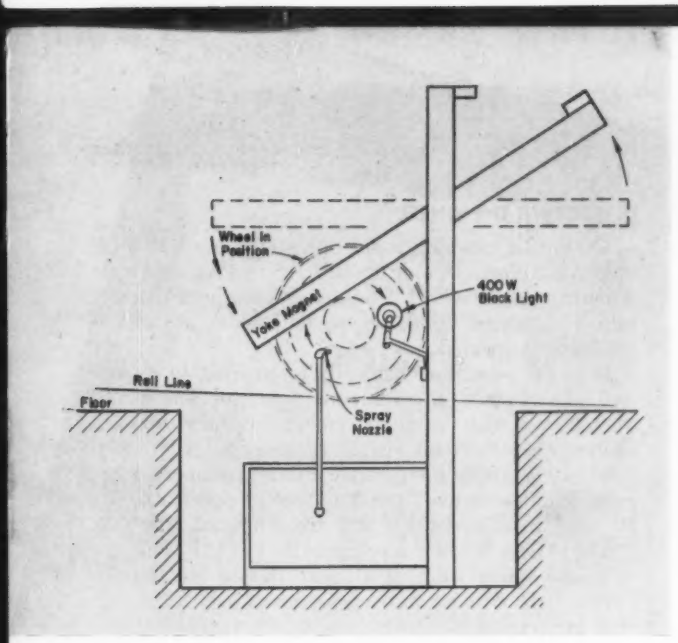
Foamed metal is poured to density range of 12 to 70 lb per cubic ft.

MAGNETIC-PARTICLE INSPECTION PACES PRODUCTION LINE AT GRIFFIN WHEEL

A. J. Panozzo / *Chief Inspector*
Griffin Wheel Co.
Chicago

If casting inspection is going to keep pace with a production speed-up, then the inspection department must modernize its techniques. Griffin Wheel Co., Chicago, has solved this problem with installations of new high-speed magnetic-particle inspection lines.

The shipment of a top quality chilled cast-iron freight-car wheel has been synonymous with Griffin Wheel since its inception some 80 years ago. Therefore, it was only fitting that the same high quality would carry thru to the E Q S (Electric Quality Steel) wheel.*



This high-speed magnetic-particle inspection equipment checks a cast steel car wheel every 60 seconds

The new product brought additional responsibilities of establishing a thorough inspection procedure and setting up certain standards whereby every E Q S wheel shipped would be of top quality and render the ultimate in service.

Since the method of manufacture and pouring produces a sound homogeneous casting generally free from shrink and other internal defects, Griffin Wheel's principal concern was to establish an inspection practice that would disclose all surface irregularities and discontinuities.

THE EQUIPMENT

A unit was designed especially for the inspection of cast steel railroad car wheels, using the continuous wet method of fluorescent magnetic particle inspection. The unit handles 55 to 60 wheels per hour on a production basis.

A schematic drawing of the special machine is shown. It features an 8000–ampere turn coil, counterbalanced in a boom swung in a structural frame which is raised and lowered by an air cylinder. A track and side rails facilitate delivery of wheels to the unit and a revolving mechanism holds and rotates wheels during inspection. An ejecting arm ejects the wheel after inspection when the magnetic coil is raised. The special power pack combines the components necessary to provide low voltage, high amperage AC for magnetizing.

An automatic sequence of operations, controlled by components in the power pack, governs the raising and lowering of the coil, application of inspection bath, magnetizing current and the ejection of the wheel after inspection.

Using Black Light

A foot switch initiates the dual automatic cycles of inspection and disposal. The inspection bath is contained in a built-in 10 gallon tank. A wide clearance impeller type pump circulates the solution which is applied by fixed sprays.

The unit sets in a pit about 44 in. deep to allow handling wheels on floor level rails. A complete enclosure provides maximum darkness for inspection with 400-watt, 12-1/4-in. black lights on each side of the wheel.

A water suspendible magnetic particle solution is used. Solution is constantly checked to assure proper concentration and test wheel, having known indica-

*The EQS wheel is classified in railroad literature as the Type "A"--33" One-Wear Cast Steel Freight Car Wheel, covered by Association of American Railroad specifications M-208-58. "EQS"—Registered trade mark U. S. Patent Office.

Conveyors move the wheels through the cleaning room.

tions, is sent thru at frequent intervals to further insure accuracy of inspection.

INSPECTING THE WHEEL

The initial cleaning room operation entails a thorough shot blast cleaning to entirely remove any scale adhering to the wheel. The wheel then goes directly into a darkened booth where both sides are simultaneously inspected.

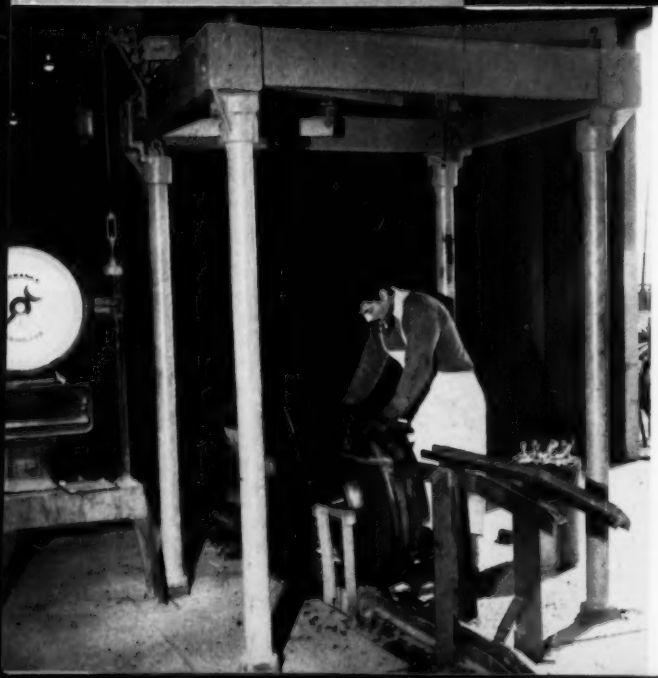
Here the wheel mechanically rotates within a magnetic field while a continuous spray of fluorescent magnetic particle solution discloses surface discontinuities not otherwise visible to the eye. All indications are carefully interpreted. From experience those requiring corrective grinding are marked; highly stressed areas and fillets are given special attention.

The wheel is then mechanically ejected from the unit and while rotating at next station outside the booth, it is visually inspected and gaged. Inspection data pertaining to the wheel is recorded and wheel is routed thru the cleaning room.

Inspection by fluorescent magnetic particle method follows cleaning.

After inspection and gaging, the wheels return to cleaning room.

Visual examination of surface is final inspection of finished unit.

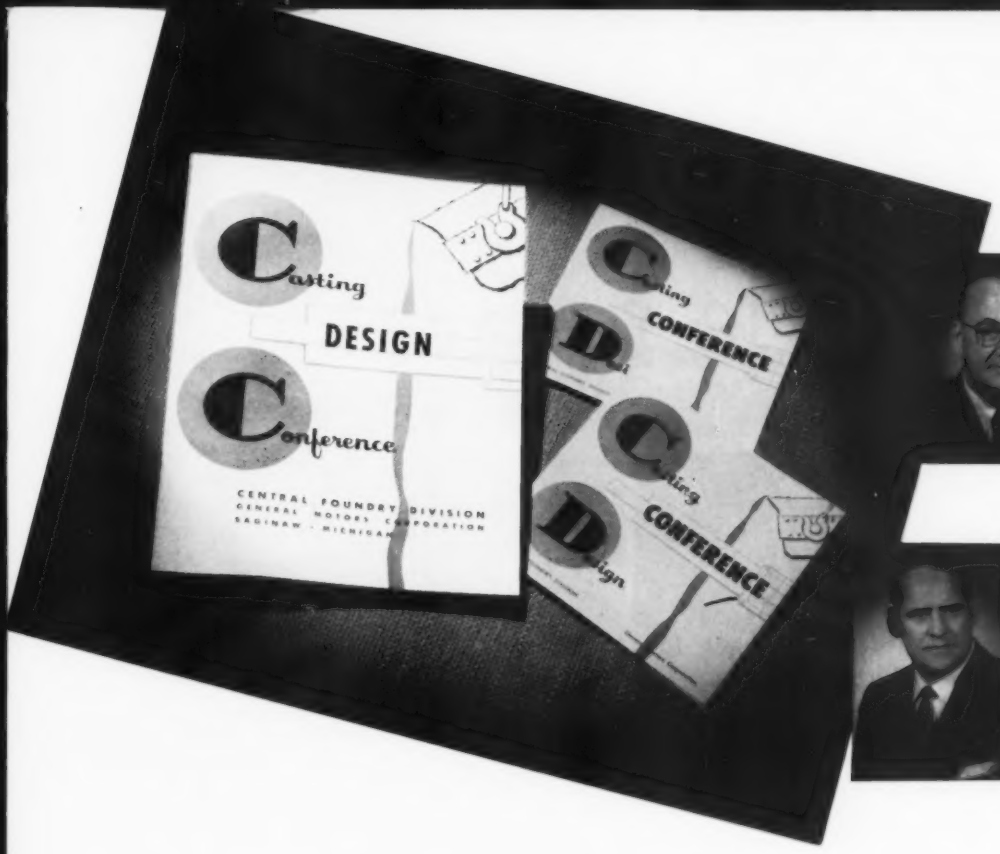


FINAL ACCEPTANCE

Wheels are conveyed through the cleaning room in a horizontal position on conveyors. The inside conveyor is for wheels which had discontinuities revealed. They are ground, recleaned and again given magnetic particle inspection. The center conveyor is for rejects, and the outside conveyor is for stock wheels where minor imperfections are ground and wheels gauged for roundness and warpage.

Wheels continue on the stock line conveyor horizontally. Mechanically brought to the vertical position they proceed by gravity to a weighing station. Actual weight and exact circumference are paint-stamped on both the front and back plate of wheel. Bore size is also paint-stamped on front hub. Wheel is given a final complete visual surface inspection as shown.

Wheels are then stored ready for shipment to the various railroads where they will keep the nations freight rolling for many years to come. ■ ■ ■



JAMES H. SMITH / *General Manager*

ELMER E. BRAUN / *Works Manager*

Central Foundry Division
General Motors Corp.
Saginaw, Mich.

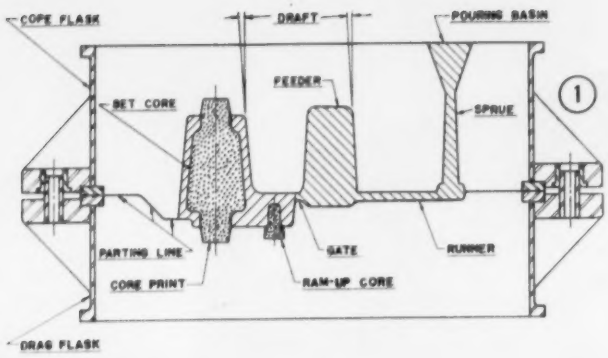
...Another Creative Selling Tool

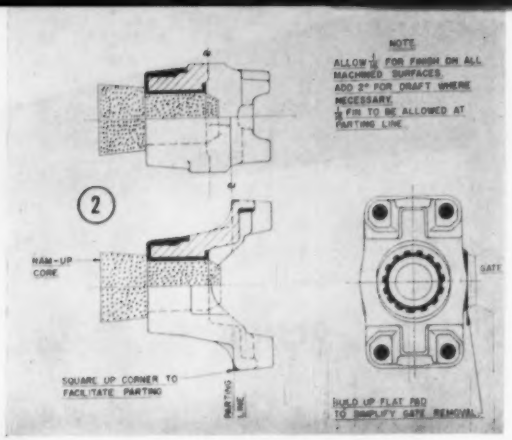
Foundrymen have failed to keep pace in an economy which has been generally moving upward over the past ten years. Building a superior product is no longer enough—salesmanship of the highest order is needed to market our products. There is an appalling lack of knowledge concerning products, processes and capabilities of the metalcasting industry. In many cases the casting buyers and users have never been in a foundry, have no idea how a casting is made, and above all are not familiar with the capabilities of our process. This is a hurdle that the best salesman in the world would have difficulty surmounting.

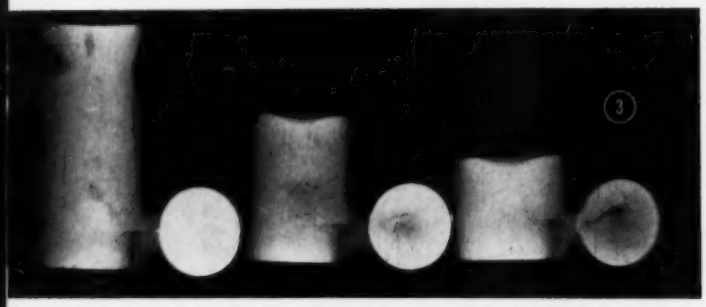
Cast products are capable of replacing, to the customer's advantage and to the ultimate consumer's advantage, many weldments, forgings, stampings and fabrications currently in production.

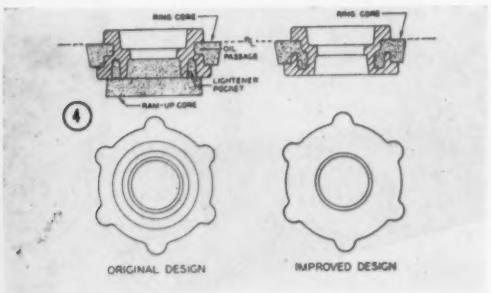
From a manager's viewpoint there are only two ways to maintain or increase the net return on the investment in our plants. One way is to cut operating costs. The other way is to maintain or increase profitable sales, and this is the key to our future.

The most important consideration in regaining our market posi-




NOTE
ALLOW 1/16 FOR FINISH ON ALL MACHINED SURFACES. ADD 3° FOR DRAFT WHERE NECESSARY. 1/16 FIN TO BE ALLOWED AT PARTING LINE
2
RAM-UP CORE
GATE
SQUARE UP CORNER TO FACILITATE PARTING
BUILD UP FLAT PAD TO SIMPLIFY GATE REMOVAL





tion is the type of selling job we do. It is imperative to do a more creative selling job. Here is the approach that Central Foundry Division, GMC, has taken to help create new sales. An effective sales program must be based upon education and finding ways to be helpful to our customers. To accomplish this, Central Foundry has adopted the principle of providing ideas, facts and suggestions to its customers.

Here are some of the results of this type of thinking. First of all, the experimental and development department expanded to incorporate such new techniques as Cobalt 60 radiography, stress analysis and dynamic testing. These new "tools" improved our foundry practices and more important still, broadened our field or application through weight reduction, improved quality and lower costs.

Product Development

Be familiar with the "forward planning" programs of your customers. You can develop many new applications only if you are consulted by your customer's designers and engineers concerning advanced model design. To encourage this practice, Central Foundry established a "Product Development Group" comprised of engineers with extensive foundry experience. This group constitutes a task force which has two major responsibilities:

1) Working with customers' engineers and designers on major new programs to develop facts, statistics and samples which will prove that castings can do a better job in many applications not previously considered, and
2) Concentrating their talents on any jobs which might appear to be in jeopardy due to proposed conversion to other materials, processing problems, costs and other factors.

The next step was to develop a strong, well-trained sales organization composed of qualified sales engineers with up-to-date product knowledge and processing information.

Still, it was apparent that some sort of a showcase was needed for our wares—a way to let the key people in our customers' organizations know what we were doing and what we could do for them. The following facts need to be established:

1. That today's modern foundry can and is providing castings of a uniform high quality.
2. That casting process has inherent advantages over other methods of shaping metals.
3. That the cost of castings can be reduced by proper design and the allowance of practical tolerances.
4. That castings can be used advantageously in many applications frequently overlooked by engineers and designers in the past.
5. That substantial reductions in weight are possible through the use of castings, stress analysis, and shell molding.
6. That it's possible to perform many operations on castings previously not thought possible.

Getting these ideas across was not a job for a "shot gun" approach; it needed a "rifle" approach—one that would reach the right people—the customer's engineers, designers and buyers.

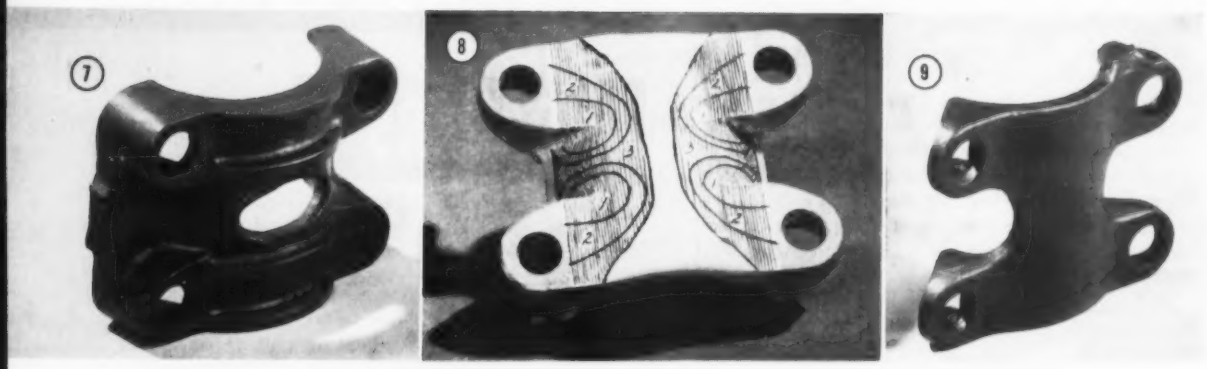
Casting Design Conference

Such an approach was created by establishing a "Casting Design Conference." This conference was organized to bring the customer's engineers, designers and buyers into the Saginaw plant of Central Foundry for a full day. The day was planned to convey ideas, present information and let guests look over the casting facilities.

The customer response has been phenomenal. To date 13 conferences have been held at Saginaw and more are being planned.

Over 1100 customers' representatives have attended these conferences. At the sessions, design engineers were out-ranked by presidents, vice-presidents, plant managers, works managers, chief engineers, directors

ADJUSTER NUT
SAND CAST DESIGN



of purchasing, chief metallurgists and master mechanics.

The Casting Design Conference program encompasses a full day which includes a tour of the GMC Saginaw Malleable Iron Plant. Talks are made by top Central Foundry men—and time is allowed for questions and answers following each presentation; also for a general discussion period at the end of the program. At this important period the exchange of information which takes place is most enlightening.

Figure 1 is typical of several used to explain basic foundry terms and practices. The mere fact that such indoctrination is needed highlights the lack of information concerning foundry operations which exists in engineering circles.

Designing the Casting

When Central Foundry receives a machined-part drawing from a customer, the markings shown on Fig. 2 are added. The most practical parting plane is determined and the parting line is marked on the print. Knowing the location of the parting line, the casting user is in a better position to design chuck jaws and establish trouble-free locating points. Cores are also added to the drawing. The best place to gate this part is at the tube and flange junction. This surface is contoured so that gate removal would be expensive, therefore the customer is asked if it would be permissible to build up to a square pad which would allow the gates to be snag ground at a fast rate.

Numerous examples are presented to demonstrate to engineers why practical foundry considerations should be taken into account in the design of a casting. Fig 4 shows how to avoid the use of a "ram-up" core. The lightener pocket was combined with a circular-oil passage so thay could be formed by a single "ring" core—thus reducing the cost of the casting.

Suggestions of this nature normally do not affect the part functionally and often will reduce the cost of the casting by a considerable amount. Cooperation between the casting designer and the foundry engineer often results in substantial savings to the customer.

Radiography

Cobalt 60 radiography is used for inspection purposes; also to assist in developing proper gating and improving design.

Figure 3 is a radiograph of three castings made with varying heights of feeders. Notice how internal shrinkage becomes apparent as the feeders are reduced. On the left is a sound casting, the middle casting shows slight internal shrinkage as indicated by the dark spots, and the right-hand casting is an example of severe internal shrinkage. Use of Cobalt 60 radiography has drastically reduced the time required in checking castings, does not destroy the part, and gives positive location of any defects.

Shell Molding

The shell molding process was also thoroughly discussed. The rapid development of the process is illustrated by the fact that over 36,000 tons of shell-mold castings were produced in 1957 by Central Foundry Division. If no machining can be eliminated, and castings made by either green sand or shell perform satisfactorily in service, then it is obvious that conversion to the shell process would be impractical.

A good example of casting improvement by converting from green sand to shell molding is the adjuster nut for conventional automotive steering shown in Fig. 5. Section thicknesses exceed strength requirements of the part but green sand molding considerations did not permit further lightening of the casting without the use of cores. Draft angles on this green sand design vary from 2° to as much as 10°.

The shell process version of the same part shown in Fig. 6 uses draft angles of 1° and has deeper pockets in the areas where excess metal previously existed. It is evident that the weight has been considerably

reduced, machining stock is less, and the hexagonal portion is more accurate for wrench application. This shell casting could be sold at a lower cost than the original green sand design.

The shell process, however, is not a cure-all. Shell castings, due to the high cost of shell material, are generally more costly than green-sand castings. At the same time, additional cost can often be more than offset by the elimination of cores, reduction of machining, reduction of casting weight, or a combination of all three. Each job must be considered individually before a proper decision can be reached.

Designers and buyers can hardly be blamed for feeling a bit confused about foundry tolerances. Casting tolerances are an important but controversial subject which handbooks and manuals treat in widely varying and ofttimes ambiguous manner.

The chart below lists the general tolerances Central Foundry is able to hold on malleable iron, ArmaSteel

GENERAL TOLLERANCE CHART

Size of Casting	Green Sand	Shell Casting
0" to 1"	±0.023	±0.006
1" to 2"	±0.030	±0.012
2" to 3"	±0.030	±0.018
3" to 8"	±0.045	±0.030
8" to 12"	±0.060	±0.041

and gray iron castings made in green sand and shell molds.

Stress Analysis

Many of our automotive castings are redesigned in the Stress Analysis Laboratory which is a part of our Experimental and Development Department. Automobile weight and methods by which weight reduction can be obtained are becoming of increasing importance. Redesign, based on stress analysis, and conversion of existing parts to higher-strength ferrous metals is helping solve this problem.

In one case, six typical automotive parts were studied from the angle of weight reduction by conversion to pearlitic malleable. Redesign saved a total weight of 20-1/2 lb on these six parts.

In stress analysis parts are coated with brittle lacquer and placed in a test fixture where simulated service loads are applied. As load is applied, cracks develop in the lacquer coating, in patterns, which make it easy to determine which areas of the casting are under the greatest stress. In Fig. 8 the crack lines have been inked in to make them clearly visible.

Using stress analysis, the casting (Fig. 7) was redesigned to the final shape shown on the right in Fig. 9. It proved to be 42 per cent lighter and 35 per cent stronger—thus giving our customer a more economical and stronger part.

This is but one of many examples showing how we use stress analysis to design castings which are stronger, lighter and less expensive.

Perhaps this Central Foundry sales approach has given you an idea or two which will prove useful. We foundrymen have a big job to do—and it can be accomplished better, faster, if we work together for the common good of all. ■■■

1959 CASTINGS CONGRESS PAPERS

■ The technical articles appearing in this preview section of MODERN CASTINGS are the official 1959 AFS Castings Congress papers—the most authoritative technical information available to the metalcasting industry.

Nearly 100 technical papers scheduled for presentation at the 63d Castings Congress of the American Foundrymen's Society at Chicago, April 13-17, 1959, will first be officially preprinted here.

■ Readers planning to participate in oral discussion of these papers during the 63d Castings Congress are advised to bring them to the technical sessions for ready reference.

■ Written discussion of these papers is welcomed and will be included in the publication of the 1959 AFS TRANSACTIONS. Discussions should be submitted to the Technical Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

MASS EFFECT ON CASTINGS TENSILE PROPERTIES

a rationalization

By G. W. Form, P. J. Ahearn and J. F. Wallace

ABSTRACT

Previously published data on the effect of section size on the tensile properties of cast metals was considered to rationalize the effect of mass on these properties. Analysis of this information indicated that solidification time was of greater significance than section size. Accordingly, section-size data were converted to solidification times, and the influence of this latter casting condition on tensile properties was evaluated. A study of the relations between these factors resulted in the formulation of a hypothesis for predicting the sensitivity of tensile strength to solidification time.

It has been postulated that tensile strength is reduced by increasing solidification times if the ductility during tensile testing is insufficient to exceed the necking strain. However, as long as the metal is sufficiently ductile to exceed this limiting value, the tensile strength is virtually unaffected by changing solidification times. This hypothesis has practical value by permitting the prediction of the tensile behavior of a cast metal at various section sizes on the basis of limited test data.

INTRODUCTION

The influence of section size on the tensile properties has been shown by several investigators.[1-13] It is notable that the effect of mass on strength and ductility differs widely from one metal to another. For instance, tensile strength of gray iron decreases by over 40 per cent if the thickness of the casting is increased from ¼ to 1¼ in.[1,2] The strength of nodular iron of similar chemical composition, on the other hand, is little affected by changing the section size.[3]

The mechanism whereby the tensile strength and ductility is affected by different casting thicknesses is generally discussed in each of the references.[1-13] The role of section size on the graphite flake size and matrix structure has been shown. The slightly lower ductility in heavy cast-steel sections has been attributed to the larger grain size and greater concentration of nonmetallics compared to lighter sections. Recent work has brought out that a more rapid rate of solidification of aluminum alloys[12] refined the size and distribution of intermetallics, thereby improving tensile properties. It has also been shown that faster solidification rates of magnesium-aluminum-zinc alloys reduce the grain size and concentration of intermetallics[11,13] and result in improved properties.

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These references, however, fail to consider some characteristics of the tensile test itself that can explain many factors of this section sensitivity. These features of the tensile test will be discussed, and the characteristics will be related to the section sensitivity of several cast metals. It will be shown that knowledge of the tensile properties of the cast metal at one thickness (eventually two thicknesses) can be employed to predict within reasonable limits the tensile properties of that same metal at other thicknesses.

SECTION SIZE EFFECT

When considering the section size and its effect on tensile properties, it is wise to distinguished between two results of widely different origin. First, the strength of materials is known to be subject to a purely geometrical size effect, illustrated by a decrease in fracture strength as the specimen size is increased.[14] This effect is not associated with variation in metallurgical structure, since it occurs in a series of specimens machined from a stock which is homogeneous throughout.

This drop in fracture strength can be readily explained on the basis of Griffith's fracture hypothesis for brittle materials,[15] which uses the concept that internal flaws are invariably present in a material. The larger such a flaw (incipient crack), the lower the applied normal stress necessary to propagate it, i.e., the lower is the fracture strength. Since the probability of a large flaw of suitable orientation being present increases with the size of the specimen, the fracture strength is expected to decrease as the dimensions of the specimen become larger.

The size effect can also be explained by the probability of the occurrence of inhomogeneities or dislocations rather than cracks. This purely geometrical size effect is particularly pronounced in brittle materials.

The second effect is connected with the size of the casting (not that of the specimen), and can be demonstrated by performing a series of tensile tests on specimens of identical dimensions taken from castings of various section sizes. This effect may be called "metallurgical size factor," in contrast to the geometrical size factor.

SOLIDIFICATION RATE EFFECT

On the basis of many published results,[1-7] one is led to assume that a unique relationship exists between tensile strength and size of a casting. However,

TABLE – CHEMICAL COMPOSITION OF MATERIALS CONSIDERED IN THIS PAPER

Material	Chemical Composition, %	Remarks
Aluminum – 4.5% copper (grain-refined)	Cu-4.5, Fe-0.3 Si-0.4, Ti-0.1	Solution heat treated and aged for 12 hr at 310 F.[9]
Medium Carbon Steel	C-0.27, Mn-0.63 Si-0.22, Al-0.3	Annealed at 1650 F for 1 hr per in. of section.[5]
Magnesium-AZ-92 Alloy	Al-9.21, Zn-2.07 Mn-0.14, Si-0.012	Solution heat treated and aged for 4 hr at 500 F.[11]
Nodular Iron	C-3.30, Si-2.78, Mn-0.26, Mg-0.051, Ni-0.890, P+S <0.1	Heated to 1768 F for 1 hr, furnace cooled to 1350 F and held for 5 hr (Annealed for high ductility).[3]
Gray Iron	A.S.T.M. Spec. A48-56, Class 30	Arbitration bar B. As-cast.[2]

recent studies[10,11] have shown conclusively that this is not necessarily the case, since the tensile strength of aluminum and magnesium sand castings were greatly altered through chill action. In special cases, identical strength values may result in castings of widely differing section size. It follows, then, that tensile strength and size of casting do not relate uniquely to one another for a given cast metal.*

A surprisingly good correlation is obtained, on the other hand, if tensile strength is plotted against time of solidification. This correlation holds irrespective of whether an alloy is cast with or without chills. This evidence suggests that the important parameter controlling the strength of a casting is time of solidification, not section size. In order to check this point further, data were collected from the literature which permit a correlation between tensile strength and freezing time. Since most available results relate strength to section size, it was necessary to convert the latter into time of solidification. Such a conversion was made possible through published data.[9,17]

The Table lists the composition of the five materials for which the desired relationship could be established. The corresponding tensile strength results are plotted vs. solidification time in Fig. 1. The metals were selected in a heat-treated condition to avoid any influence of cooling rate below the solidification temperature. In order to evaluate only the solidification time effect, it was desirable to avoid the effect on tensile properties, produced by more rapid cooling through the critical temperature range (eutectoid transformation) in the ferrous alloys, and differences in cooling from a single solid solution phase or region into a two-phase region in the nonferrous alloys.

Nodular iron and steel were selected in the annealed state, and the aluminum and magnesium alloys in the solution heat treated and precipitation hardened condition for this reason. Only in gray iron was it necessary to use as-cast data because of lack of available information in other conditions. It is evident from Fig. 1 that a unique relationship between strength and freezing time, as proposed,[10] holds for all five materials over the range investigated. Furthermore, if the same data are replotted on a semi-logarithmic scale, as shown in Fig. 2, a straight line relationship results, which can be expressed by the equation:

$$\text{Tensile strength} = a - b \cdot \log t$$

where: t = freezing time in min (always a finite number).

a = tensile strength in psi after a solidification time of 1 min.

The slope of the straight lines, given by the con-

*It has also been shown that average thermal gradients in the solidifying casting do not correlate with tensile strength.[10,16] The actual thermal gradient at the instant of solidification is significant in determining the tensile strength but is difficult to determine experimentally.

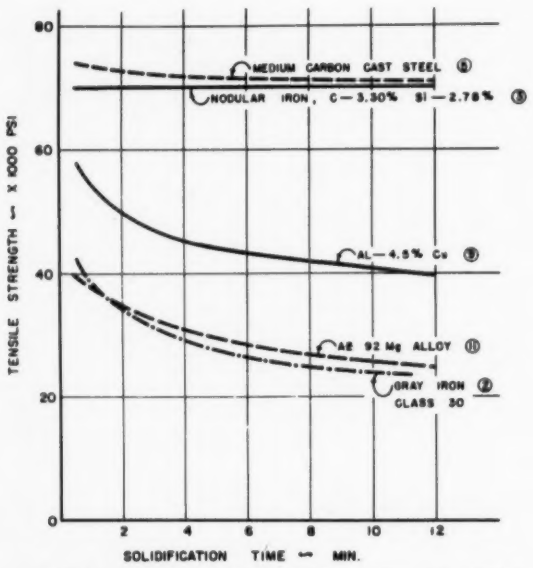

Fig. 1 — Effect of Solidification time on tensile strength of various cast metals.

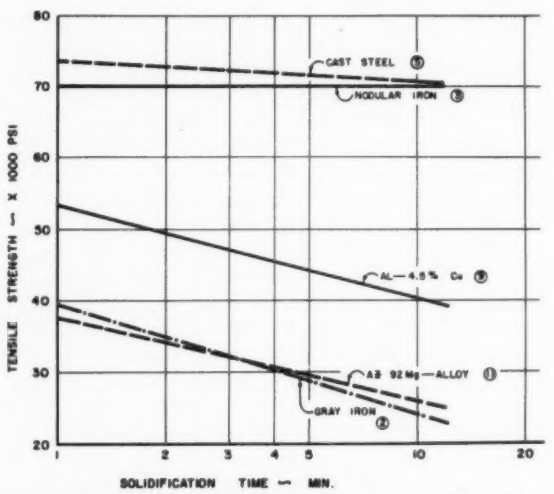

Fig. 2 — Semi-logarithmic plot showing the effect of solidification time on tensile strength.

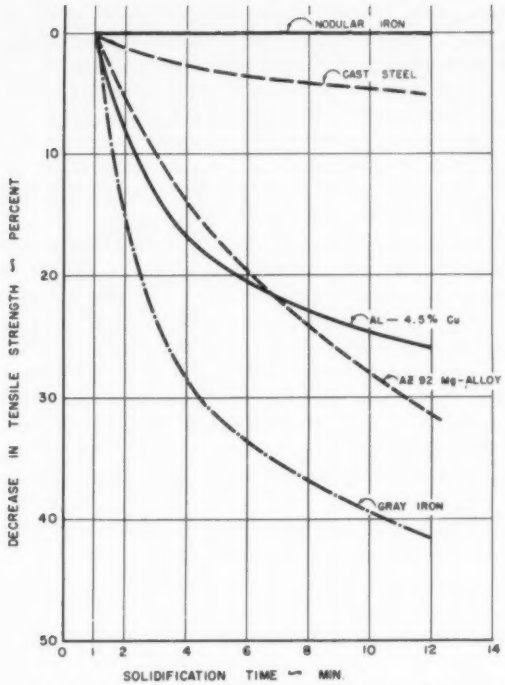

Fig. 3 — Per cent decrease in tensile strength as a function of solidification time for various cast metals.

stant b, could be taken as a measure of the sensitivity of strength to metallurgical size factor, since it indicates the rate of change of tensile strength with freezing time. This is not a practical choice, however, since a drop in strength from 100,000 to 95,000 psi would be expressed by the same value of b as a drop from 10,000 to 5,000 psi over the same interval of t. Yet, the low-strength material would obviously be classified as more sensitive to metallurgical size factor than the high-strength material.

The precentage drop in tensile strength with freezing time was, therefore, considered a more appropriate parameter to express the sensitivity of the tensile strength. A plot of per cent decrease in tensile strength vs. solidification time is shown in Fig. 3. The strength for a freezing time of 1 min was arbitrarily selected as 100 per cent. This graph shows clearly that gray iron, aluminum – 4.5 per cent copper, and commercial AZ-92 magnesium alloy are strongly affected by time of solidification in contrast to nodular iron and cast steel. The tensile strength of the two latter materials was altered little over the range of freezing times investigated.

TENSILE TEST CHARACTERISTICS EFFECT ON SECTION SENSITIVITY

The influence of solidification time on tensile properties is considerably affected by the characteristics of the tensile test itself. The tensile strength is defined as the ratio between maximum load and original cross-sectional area of the test specimen. This implies that the tensile strength can be computed from an engineering stress-strain curve only if the maximum load is really attained in a tensile test. In order that

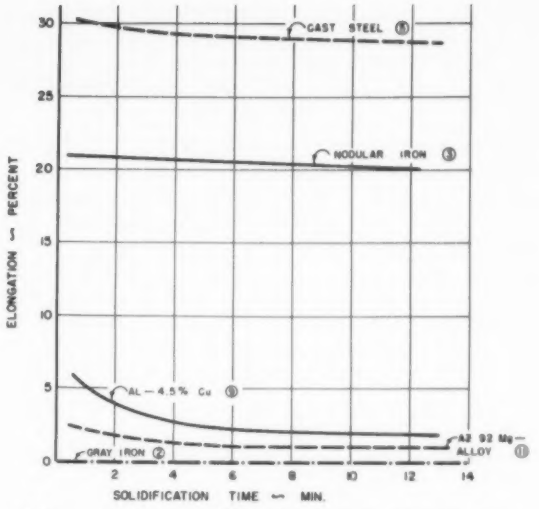

Fig. 4 — Effect of solidification time on per cent elongation of various cast metals.

the maximum load be attained, it is necessary that the ductility of a material at fracture be sufficient to at least reach the necking strain. The necking strain also is the strain at which the rate of increase in load carrying ability due to strain hardening is just equal to the rate of decrease of load carrying ability because of reduction of the cross-section of the test bar. At higher strains, the effect of reduction in cross-section predominates and the total load decreases.

It has been shown that an increase in freezing time will, in addition to producing other modifications in metallurgical structure, produce a larger as-cast grain size. This larger grain size will generally exhibit decreased ductility, since increasing grain size reduces the total grain boundary area. For a given composition, this produces a higher concentration of grain boundary segregates, providing more concentrated planes of weakness in the metal.*

As long as the fracture elongation remains larger than the necking strain, an increase in freezing time (no matter how much it affects ductility) will not reduce the maximum load or tensile strength appreciably. If fracture elongation falls below the necking strain, however, the tensile strength is influenced by the freezing time. This hypothesis proposes that a critical ductility value exists at the necking strain or the strain at which the loss in load carrying ability, because of the smaller cross-sectional area of the specimen, exceeds the increase in load carrying ability from strain hardening. When the cast metal has a lower ductility than this critical value, the tensile strength becomes sensitive to the metallurgical size factor.

In order to check this theory, ductility values for the five metals considered were plotted against time of solidification (Fig. 4). It can be seen, that those materials such as gray iron and the aluminum and

*It must be appreciated that a thorough study of the metallurgical processes taking place during freezing is necessary to assess their resultant effect on mechanical properties.

magnesium base alloys, whose tensile strength is strongly affected by freezing time, display low fracture ductilities. In contrast, the strength of nodular iron and cast steel is little influenced by solidification time, and also exhibit high ductility.

It is difficult to predict the magnitude of necking strains without the stress-strain curves for these materials. However, it is doubtful that materials with less than about 5 per cent elongation reached maximum load before fracture. Consequently, the respective strength data for these more brittle metals in Figs. 1-3 do not indicate tensile but fracture strengths. In other words, the stress-strain curve for these materials intersects the brittle strength curve before maximum load is attained.

The effect of freezing time on tensile strength can be analyzed on the basis of this concept. It is appropriate to distinguish between the following possible influences of freezing time on the tensile properties of cast metals.

1) Neither tensile strength nor elongation are affected by variation in solidification time.
2a) Only elongation is affected.
2b) Only tensile strength is affected.
3) Both tensile strength and elongation are affected.

Behavior (1) is unlikely over a wide range of freezing time, for reasons previously mentioned, although it may be approached over a limited range. Behaviors (2a) and (3) can be demonstrated with the aid of true stress-strain curves. The four schematic curves in Fig 5a represent behavior (2a) for different freezing times. They illustrate how tensile strength is little affected as long as elongation surpasses the necking strain even though the fracture strength and ductility are reduced.

Figure 5b depicts behavior (3) and shows that what is commonly considered a decrease in tensile strength is really a drop in fracture strength, if the maximum load is not attained during tensile testing. Behavior (2a) is typical for ductile materials, while behavior (3) is characteristic of the more brittle metals. A transition from behavior (2a) to (3) is to be expected, if ductility is strongly affected by solidification time or if the necking strain is barely exceeded at short freezing times. This latter case is schematically illustrated in Figure 5c.

On the basis of the above hypothesis, the five metals may be classified:

a) Cast steel and nodular iron follow the pattern of behavior (2a).
b) The magnesium alloy, AZ-92, typifies behavior (3).
c) The aluminum alloy may either be classified as

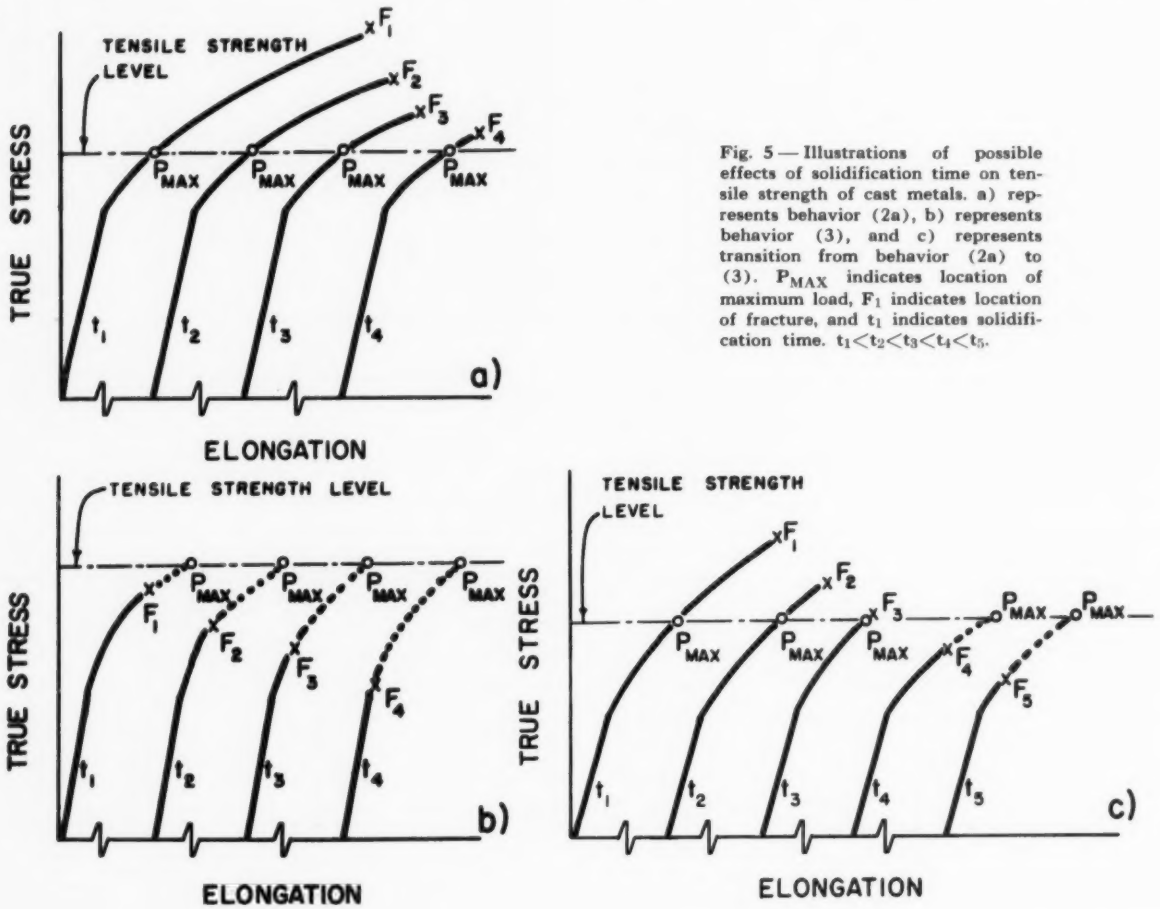

Fig. 5 — Illustrations of possible effects of solidification time on tensile strength of cast metals. a) represents behavior (2a), b) represents behavior (3), and c) represents transition from behavior (2a) to (3). P_{MAX} indicates location of maximum load, F_1 indicates location of fracture, and t_1 indicates solidification time. $t_1<t_2<t_3<t_4<t_5$.

case (3) or as a transition from case (2a) to (3), depending upon whether or not 6 per cent elongation (for t = 1 min) exceeds the necking strain of the alloy.

d) Gray iron may appear, upon first examination, to be typical of case (2b), since its tensile strength is strongly affected by freezing time and the ductility remains unchanged. However, from the illustration given in Fig. 5, it is unlikely that behavior (2b) is displayed by any material. Gray iron should be classed in case (3). In brittle materials such as gray iron, changes in ductility, if they occur, are of the order of a fraction of 1 per cent, and are therefore not only hard to assess but also subject to considerable scatter. It is also entirely possible that a given material can behave as one class at one strength level and exhibit a different behavior at another strength. It is suspected, for example, that ultra-high-strength steel will have characteristics similar to case (3) whereas low-strength steel falls into case (2a).

SUMMARY

The hypothesis developed states that the sensitivity of the tensile strength of a cast metal to the solidification rate of the casting depends on whether the metal has sufficient ductility to attain or exceed the strain at necking. Utilizing this hypothesis, the sensitivity of a cast metal to solidification time or a metallurgical size factor can be assessed by a limited amount of tensile testing.

If the elongation of the tensile specimen from a rapidly solidified casting is less than the necking strain, the tensile strength will decrease with longer freezing times. If the fracture elongation exceeds the necking strain for this rapidly solidified bar, a second test of a specimen from a thicker section is necessary to classify the metal as sensitive or insensitive to freezing time. This hypothesis is based on the assumption that the stress-strain relationship is not appreciably altered by freezing time. This assumption is correct as far as known, but requires further investigation.

This theory is of practical value to metallurgists, since the prediction of tensile properties at various section sizes is possible from limited data. Such information can be employed to select cast metals for given applications and for alloy development.

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RAPID HYDROGEN DETERMINATION FOR STEEL FOUNDRY CONTROL

By C. C. Carson and B. J. Alperin

ABSTRACT

A method is described for the determination of hydrogen in steel which is rapid, simple and economical. The method uses the hot extraction technique for extracting hydrogen from steel, and employs a Pirani gage for the analysis of the extracted gases for hydrogen by the thermal conductivity technique. The furnace section is made a part of the gas collecting volume. Comparison of results with those obtained with a conventional apparatus and procedure employed for the hot extraction technique show satisfactory agreement. For a sample size of approximately 2 g, the determination is completed in 5-10 min from the time that the sample enters the hot zone of the furnace. The time from the sampling of a molten bath to the completion of an analysis is about 15 min.

INTRODUCTION

As a result of the widespread interest in the significance and behavior of hydrogen in steel, there is a growing need for an economical, simple and rapid method for the determination of hydrogen in steel suitable for quality control purposes in a foundry. This paper describes a method that is being used in a steel foundry operated by the authors' company. The method is based on the hot-extraction technique for the extraction of hydrogen from steel, and on the thermal conductivity technique for the analysis of the extracted gases for hydrogen. An analysis can be completed in about 15 min from the time of sampling of a molten bath. The results compare satisfactorily with those obtained with a conventional hot-extraction apparatus for the extraction of the hydrogen, and a fractionation procedure for the analysis of the extracted gases.

The apparatus developed differs from the conventional hot-extraction apparatus in that the furnace section is a part of the gas-collecting volume, thereby eliminating the need for a diffusion pump, or a Toepler pump, for the transfer of the gases from the furnace section. Also, the analysis of the extracted gases by the thermal conductivity technique is accomplished with an economical, commercially available Pirani gage. Only one pump, a mechanical vacuum pump, is used. The cost of the apparatus is about half, and the time for analysis is less than half by comparison with a conventional hot-extraction apparatus employing the fractionation technique for the analysis of the extracted gases.

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ANALYTICAL METHOD CHOICE

Gas Extraction From the Sample

The three techniques commonly employed for the extraction of hydrogen from steel are:

1) Hot extraction.[1,2,3] The sample is heated at 600-1100 C in a vacuum.
2) Tin-fusion.[4,5,6] The sample is fused with tin in a vacuum.
3) Vacuum-fusion.[1,2,7] The sample is melted in a graphite crucible at 1375-1700 C in a vacuum.

The extracted hydrogen is normally collected in a separate volume along with varying amounts of carbon monoxide and nitrogen. The partial pressure of the hydrogen is then determined, and used in the calculation of the weight of the hydrogen by means of the perfect-gas law ($PV = nRT$).

Differences of opinion exist as to the accuracy and suitability of the three techniques, and the absence of standards has not helped to resolve these differences. It is generally conceded, however, that, at least for practical purposes, all of the hydrogen is extracted by the vacuum-fusion technique. Carney, Chipman and Grant[4,8] carried out studies on the tin-fusion technique, and determined that the method had a precision of $\pm$ 0.1 ppm and an overall accuracy (including sampling molten steel) of a few tenths of 1 ppm.

Although the tin-fusion and vacuum-fusion techniques are not as convenient, and require a more cumbersome apparatus as compared to the hot-extraction technique, they have been termed superior by some investigators[4,6] because it was believed that they were faster and more accurate than the hot-extraction technique. However, Carson[9] compared the tin-fusion technique at 1150 C with the hot-extraction technique at 975 C on samples of low alloy steel weighing 2-3 g, and found that the hot-extraction techniques gave the same results in about the same time and with a better precision.

For the purpose of designing a simple, economical and rapid procedure for the determination of hydrogen in steel for quality control purposes, it was decided to make use of the hot-extraction technique.

Extracted Gases Analysis

There are several ways which can be and are used to determine the partial pressure of the hydrogen in

A—Trap
C—Pirani tube
D—Quartz tube
E—Receptacle for analyzed sample
F—Resistance furnace
G—Mercury lift
H—McLeod Gage

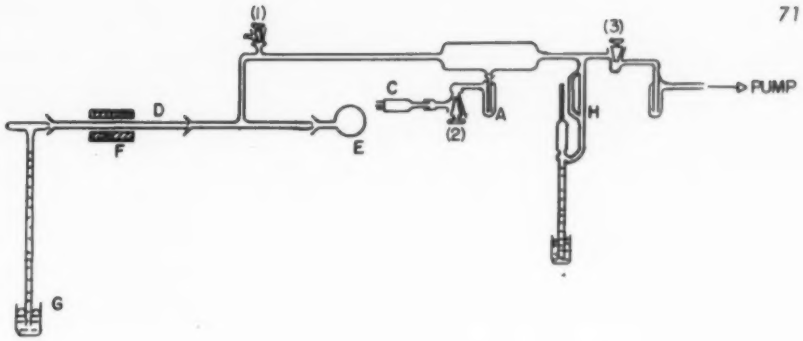

Fig. 1 — Apparatus for hot-extraction technique.

the mixture of hydrogen, carbon monoxide and nitrogen extracted from the sample. Thus, the hydrogen can be removed as it is in the so-called fractionation technique, and its partial pressure obtained either on the hydrogen removed or from the drop in the total pressure of the mixture. For another approach, a mass spectrometer can be employed to analyze the gas mixture without the necessity of separating the hydrogen from the mixture. Also, the thermal conductivity technique[10] can be employed to analyze the gas mixture for hydrogen without going through a separation step, and it was this technique which appeared to be the most suitable for the type of apparatus desired.

Shields, Chipman and Grant[10] used a special thermal conductivity cell of their own design and reported satisfactory results, obtaining a probable error of 0.12 ppm for the overall analytical method when the tin-fusion technique was employed. Carson[9] used an economical, commercially available Pirani gage for the thermal conductivity technique in conjunction with the hot-extraction technique, and observed only a small increase in the standard deviation ($\pm$ 0.03 to $\pm$ 0.11) as compared to a fractionation technique in which the hydrogen was converted to water and frozen out. This small loss in precision is not as important as the time (10-15 min per determination) that is saved for a quality control test. Accordingly, the gases were analyzed by the thermal conductivity technique using the commercially available Pirani gage.

APPARATUS

Figure 1 shows the hot-extraction apparatus which was constructed.

A major feature is the use of the furnace section as part of the calibrated collecting volume. This eliminates the need for a diffusion pump or a Toepler pump to transfer the extracted gases into a collecting volume. Not only is a simplification thereby effected, but the time for carrying out the transfer of gases is saved.

Except for the furnace section, which is made of quartz, the system is constructed of pyrex glass.

The Pirani gage has a range of 0-2,000 μ Hg. Trap A, which is used to freeze out water and other condensibles from the collected gases, also serves to protect the gage from condensibles. When the system is not in use, stopcock (2) is closed to protect the gage from vapors. Stopcock (2) has a 10 mm bore, and its hollow cavity has a volume of > 100 cc, which provides an appreciable volume of gas in the vicinity of the gage.

Stopcock (1) is used to open the system to the atmosphere and to introduce gases into the system for calibration purposes. The total volume of the system is about 1500 cc. The only pump used was a mechanical pump, and the vacuum obtained, < 0.1 μ Hg, was found to be satisfactory. The stopcocks are greased with a proprietary stopcock grease. The joints are standard taper seal 24/40 ground glass joints and are sealed with a proprietary wax.

CALIBRATIONS

The volume of the system can be determined by using the McLeod gage, according to the method described by Murray and Ashley.[11] Essentially, the method consists of expanding a gas trapped in the McLeod gage at a known pressure into the rest of the system, and calculating the total volume from Boyle's Law ($PV = K$). It was found advisable to attach a known volume of about 250 cc to the air inlet at stopcock (1). This made it possible to substantially increase the amount of gas that is trapped and then expanded into the system, thereby making possible a higher and more precise final pressure reading upon which to base the calculation of the total volume.

The calibration of the volume is carried out with the furnace at the operating temperature of 900 C. The volume thus obtained did not appear to change significantly with the pressure over a pressure range of 50-75 μ Hg.

Since the trap is immersed in either acetone at approximately – 85 C or, more conveniently, in liquid air, a correction must be added to any pressure reading to account for the fact that this part of the volume is below room temperature. This calibration is made simply by starting out with a dry, pure gas such as nitrogen at room temperature and any given pressure, then placing the bath around the trap and noting the drop in pressure. This is done for a series of pressures and a graph is constructed (Fig. 2).

Finally, a small correction is added to an observed pressure of hydrogen, to account for the fact that some hydrogen will diffuse through the hot quartz of the furnace section. This correction is directly proportional to the partial pressure of the hydrogen, and is conveniently measured as the drop in the hydrogen pressure during a 10 min period (about 1 μ Hg for a hydrogen pressure of 35 μ Hg for this apparatus).

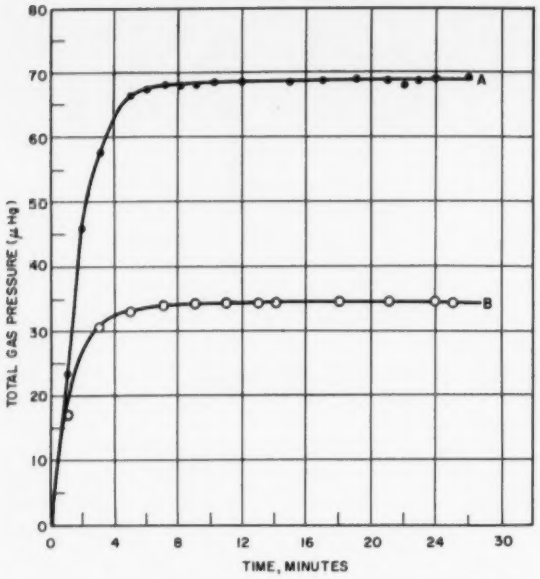

Fig. 2 — Rate of gas extraction. The pressure of the extracted gases is plotted against the time for two typical samples. A good indication of the hydrogen content can be obtained after an extraction period of about 5 min.

The Pirani gage is calibrated with nitrogen, i.e., it is attempted to have the Pirani gage read the same as the McLeod gage when nitrogen is in the system. With the Pirani gage calibrated, hydrogen is introduced into the system, and the reading on this gage is plotted against the reading on the McLeod gage for a series of hydrogen pressures. This curve, which represents 100 per cent hydrogen, is plotted on the same graph with the nitrogen calibration curve, which represents 0 per cent hydrogen. The graph is then used to determine the fraction of hydrogen in the gases extracted from a steel sample. This is possible because of the three gases extracted (hydrogen, nitrogen and carbon monoxide), two of the gases, nitrogen and carbon monoxide, have virtually the same thermal conductivity properties,[10] so that we are in effect dealing with a hydrogen-nitrogen system.

SAMPLING AND ANALYTICAL PROCEDURE

A spoonful of molten steel is obtained with a well-slagged spoon and killed with aluminum. A sample is then immediately taken from the spoon by carefully sucking (by means of a rubber bulb) some molten metal up a pyrex or vycor glass tube (¼-in. in diameter and more than 1 ft in length), then quenching the drawn sample in cold water. The steel "pencil" thus obtained can then be stored in liquid nitrogen until the time of analysis, or it can be subjected to the next step directly.

A portion of about 1 in. of the steel tube is lightly abraded on a dry grinding wheel, being careful to avoid overheating the metal. The steel tube is then placed in a vice, and about ½-in. of the abraded portion of the tube is broken off. Should a void be discovered in the sample, another sample should be taken from another portion of the tube. If care has been taken to keep the sample clean, it can be introduced directly into the analytical system via the mercury lift after its weight is obtained. If it is suspected that the sample has been contaminated (e.g., from being handled with fingers or from coming in contact with an unclean vise, etc.), then it should be washed with a suitable solvent such as acetone, and dried before being introduced into the system.

Stopcock (3) is open when the sample is introduced into the system and stopcock (1) is closed. After the gas that has been introduced into the system has been pumped out, stopcock (3) is closed, and the sample is moved by means of a magnet into the center of the hot zone of the furnace section. Extraction time is 10 min. At the end of that time, a reading is taken simultaneously on the McLeod gage and on the Pirani gage.

From the calibration graph obtained for the Pirani gage (containing one curve for 0 per cent hydrogen and one for 100 per cent hydrogen), the fraction of hydrogen in the gas mixture is determined. The use of the graph, shown in Fig. 3, will be illustrated with an example. Let us assume that the reading on the Pirani gage was 85.0 μ (point b, Fig. 3) when the reading on the McLeod gage was 50.0 μ (point a, Fig. 3). If the gas had consisted of 100 per cent hydrogen, then the reading on the Pirani gage would have been 92.3 μ (point c, Fig. 3). Therefore, the fraction of hydrogen in the gas mixture would be

$$\frac{(85.0 - 50.0)}{(92.3 - 50.0)} \text{ or } 0.829.$$

The McLeod gage reading, after being corrected for the presence of the trap, is then multiplied by

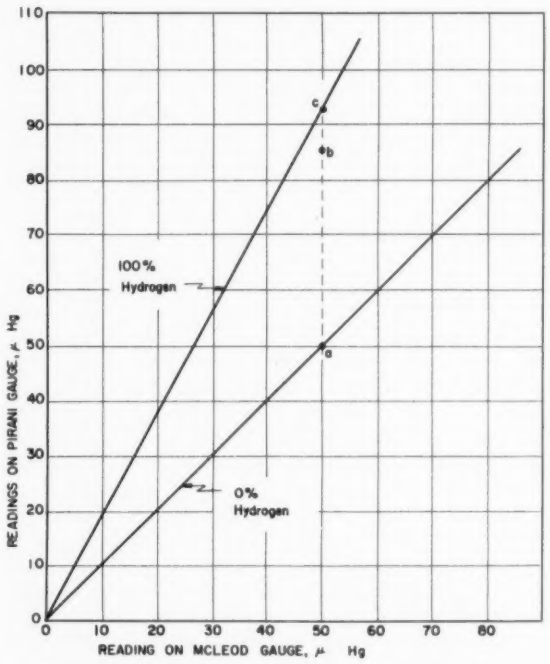

Fig. 3 — Calibration of Pirani gage for thermal conductivity method.

this fraction to give the partial pressure of the hydrogen at the time that the reading was taken. The correction for the amount of hydrogen that has diffused through the quartz is then added to this pressure to give P_H, the hydrogen pressure that is used in calculating the result. The weight of the hydrogen is calculated from the perfect gas law, $P_HV = nRT$ or $P_HV = W_HRT/M_H$, where W_H is the weight of the hydrogen, and M_H is its molecular weight. Asssuming a fairly constant room temperature, this can be put in the form $W_H = k'P_H$. Thus, the equation used in the calculation of the result is

$$(\text{ppm Hydrogen}) = \frac{k'P_H 0.10^6}{W_s}$$

$$\text{or } (\text{ppm Hydrogen}) = \frac{k\,P_H}{W_s}$$

where W_s is the weight of the sample.

After some practice, the entire determination from the time of sampling to the calculation of the result can be carried out in about 15 min.

In Fig. 2, the pressure of the extracted gases is plotted against the time for two typical samples. It can be seen that a good indication of the hydrogen content of the sample can be obtained after an extraction period of only 5 min or so, if the time is critical.

RESULTS

Table 1 compares results obtained by means of the described apparatus and procedure with results obtained with a conventional apparatus[9] employing hot-extraction at 975 C for extracting the gases and a fractionation technique for the analysis of the extracted gases. The chemical compositions of the samples are given in Table 2.

For each comparison, two samples were taken from the same pencil specimen of steel obtained as indicated in the section of this paper on sampling and analytical procedure. Tests had indicated that the hydrogen distribution is uniform along a sound pencil specimen. For example, the results obtained by the conventional apparatus and procedure on three specimens taken from one pencil were 3.2, 3.2 and 3.4 ppm of hydrogen.

It is to be noted that eight of the samples in Table 1 had hydrogen contents or 2-3 ppm. Previous studies on thermally charged specimens had indicated that in this range of hydrogen contents results obtained by the conventional apparatus have a standard deviation of ± 0.07 ppm. The standard deviation of the results obtained by the modified apparatus is therefore calculated to be ± 0.14 ppm in this range of hydrogen contents. Statistical treatment indicated that the average result obtained by the modified apparatus does not differ significantly from that obtained by a conventional apparatus.

TABLE 1 – COMPARISON OF RESULTS OBTAINED BY MODIFIED AND CONVENTIONAL APPARATUS

Sample No.	Hydrogen Content, ppm	
	Modified Apparatus	Conventional Apparatus
1	2.92	2.87
2	2.90	3.06
3	6.23	6.07
4	3.49	3.84
5	4.14	4.10
6	5.46	5.47
7	2.83	2.76
8	2.43	2.23
9	2.91	2.82
10	1.97	2.15
11	2.27	2.32
12	2.43	2.67

CONCLUSIONS

The modified apparatus described in this paper for the determination of hydrogen in steel is economical to build and simple to operate. Results obtained do not differ significantly from results obtained with a conventional apparatus. A determination can be completed in about 15 min from the time of sampling with a precision that is satisfactory for quality control purposes.

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When this paper was written, the authors included information and expressed opinions they believed to be correct and reliable. However, because of the constant advance of technical knowledge, the widely differing conditions of possible specific applications and the possibility of misapplication, neither the authors

TABLE 2 – CHEMICAL COMPOSITION OF SPECIMENS

Sample No.	Heat No.	Per Cent											
		C	Si	Mn	S	P	Cr	Ni	Mo	V	Cu	Al	Ti
1	2195	0.21	0.50	0.73	0.014	0.015	1.26	0.13	1.02	0.04	0.19	0.008	
2	2189	0.25	0.41	0.72	0.009	0.017	1.24	0.14	1.17	0.04	0.19		0.014
3	2191	0.22	0.57	0.65	0.009	0.016	1.18	0.15	1.10	0.06	0.20		0.021
4	2193	0.19	0.42	0.60	0.014	0.012	0.10	0.13	0.54	0.01	0.20		
*5		0.13	0.45	0.60	0.015	0.009	16.25	1.80					
*6													
*7													
8	2178	0.20	0.53	0.70	0.010	0.017	1.25	0.14	1.01	0.06	0.21		
9	2210	0.24	0.63	0.63	0.007	0.010	1.20	0.14	1.13	0.03	0.22		0.020
10	2205	0.18	0.35	0.73	0.008	0.017	1.30	0.16	1.05	0.18	0.20		
11	1820	0.18	0.50	0.54	0.008	0.013	1.29	0.14	1.03	0.20	0.22		0.022
12	1810	0.15	0.40	0.63	0.008	0.012	1.21	0.17	0.96	0.19	0.22	0.008	0.016

* Taken at different times during the same heat.

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TEMPERING MOLDING SAND

By H. W. Dietert, V. Rowell and A. L. Graham

ABSTRACT

Test procedures for actual and compensated moisture tests are described. The actual moisture test is recommended as standard whenever the actual total percentage of the base water and water of evaporation is required. The compensated moisture test is recommended for determining the sand moisture content without including the evaporation water. This test is recommended for moisture control at the sand mill where sand temperature fluctuates, and one desires to determine the sand moisture at the time it reaches the molding station.

A method of determining the riddled density of sand is given, and its relationship to moisture percentage shown.

The use of high-strength sands is on the increase. Tempering a high-strength sand, by holding ultimate deformation the same as for previously used lower-strength sand, yields a strong sand that retains the good flowability of lower-strength sand. The higher-strength sand will produce a better finish casting with greater contour accuracy.

Ultimate deformation is proposed as a new method of controlling the sand temper in place of using moisture percentage as the index for western bentonite, clay and natural bonded sands.

INTRODUCTION

Molding sands are tempered with water and oil, and may also be tempered with silicone liquid. The latter is not in practical use at this time due to cost. Oil is finding some practical use for tempering treated bentonite bonded sands.

Water, at the present time, is the usual means of plasticizing the bonding material in molding sands. Water softens the clay or bentonite particles, causes the particles to increase in size in many cases and enables the bonding particle to acquire a degree of tackiness and plasticity.

This study is devoted to a means for determining the amount of water suitable for molding. The temper point desired will be predicated on the degree of plasticity imparted by the water addition. Plasticity degree will be measured by ultimate green deformation of the sand.

Water added to molding sand may be divided into two parts—base water, and evaporation water.

H. W. DIETERT is Chmn. of Board, V. ROWELL is Vice-Pres. and A. L. GRAHAM is Rsch. Engr., Harry W. Dietert Co., Detroit.

Base water is necessary to plasticize the bond, and is almost wholly absorbed by the bond in the sand. A small portion is used to moisten the surfaces of the sand grains.

SAND MOISTURE

Evaporation water is that portion which is added beyond the amount needed to temper a sand, and comprises moisture lost before the sand is used for molding. The amount of evaporation water required varies greatly. The greatest requirement factor is the temperature of the sand. For example, as much as 0.8 lb of evaporation water per 1000 lb of sand may be required for some sand systems for each 10 degree rise in sand temperature up to 210 F. Above that temperature a multiple of the stated amount may be required.

The amount of evaporation water required is also increased as the atmospheric humidity decreases, and as the air current or the aeration increases. Thus, when moisture determinations are made of molding sands, particularly of sands above room temperature, attention should be given to the fact that water in molding sand consists of two parts, base and evaporation water.

At the time of mixing the sand, one is interested in preparing a sand that will reach the molding station with the correct degree of temper. To accomplish this, sufficient evaporation water must be added at the time of mixing. Correctly understood, moisture tests are a great aid.

MOISTURE DETERMINATION METHODS

Water in a sand is expressed as percentage of moisture. Moisture percentage values give foundrymen a numerical value for control purposes only. It does not express any particular mechanical property of the sand in reference to temper, but does give information as to one of the ingredients of the sand. At the present time, it is the almost exclusive means of controlling the sand temper. Thus, one should be well versed in the test procedure, and what the test values obtained really mean.

There are two fundamental test procedures, actual and compensated moisture tests. These two tests come about due to the fact that as the sand temperature increases in a sand system additional water is added to the mix to compensate for evaporation moisture loss while the sand is transported and stored.

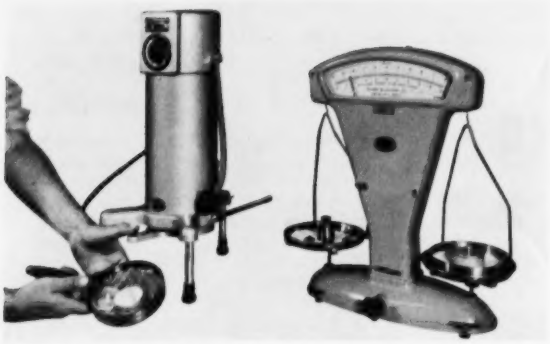

Fig. 1 — Arrangement of equipment for actual moisture test.

The actual moisture test procedure gives moisture percentage of the base and evaporation water present at time of sampling. This test is used whenever one wishes to know the sand moisture.

The compensated moisture test procedure yields results that express the percentage of base moisture in the sand. It allows the evaporation water to vaporize during the first weighing of the compensated moisture test. Thus, this test can be used at the mixing station to ascertain the sand temper when it arrives at the molding stations after it is transported, stored and ready to go into the mold. The hotter the sand, and the dryer the air, the greater will be the moisture evaporated during the first weighing operation. This also applies to the sand in the system.

It is not difficult for one to adjust the evaporation period during the first weighing operation in the compensated moisture test procedure so the test values will express sand moisture as delivered to the molder. Compensated moisture test values for a controlled sand will remain the same throughout the day as the sand temperature varies. Thus, the compensated moisture test is, at the present time, the proper moisture control tool whether one uses manual or automatic tempering.

The actual moisture test is in reality a new moisture test used to check how well the final moisture of the sand was anticipated.

SAND SAMPLING

The representative sand sample is placed in a sand-sample container approximately one quart in size. The container is immediately closed after sample is placed in it with a tight fitting cover to avoid evaporation moisture loss. Make the moisture determination of the sand sample as quickly as possible. Discard top ½-in. layer of the sample. Then quickly mix sand sample by stirring with a spatula. Immediately fill sand weighing dish 2 in. x 1 in. full of sand. Use thumb to slightly pack sand in the weighing dish. Place cover on the weighing dish. The weighing operations are different for the actual and compensated moisture tests.

Actual Moisture Test Procedure

The actual moisture test, which yields test values expressing the exact total moisture in the sand at the time of sampling, is conducted in two slightly different sample treatments during weighing—a standard actual moisture test and a control actual moisture test.

The standard actual moisture test is used for precise work. The closed weighing dish containing the test sample is placed on an analytical or similar balance and a catch weight is obtained. A tare weight is used to counter balance the moisture teller drying pan with filter paper and weighing dish with cover at room temperature. The pan, dish and cover must be stored in a desiccator to keep them moisture free before use.

Figure 1 illustrates, in the right view, how the weighing dish with cover is placed in the drying pan during the first weighing operation. The left view illustrates how the catch weight of the sand test sample is dumped in the moisture teller drying pan together with the emptied weighing dish and cover. This assembly is placed in a moisture teller or oven for drying.

After the sample is dried, cool in a desiccator and reweigh the drying pan with sand, dish and cover. The difference between the first catch weight and the dry weight, divided by the original weight of the moist sand sample and multiplied by 100 is the standard actual moisture percentage.

For control work, one can dispense with the cover on the weighing dish and cooling in desiccator. The amount of moisture loss due to an open weighing dish during the weighing operation is negligible due to the small amount of sand area exposed to the air. The operator also removes most of the top layer of the sand during the weighing operation which further reduces moisture loss during the weighing operation.

Thus, in a control actual moisture test procedure, it is permissible to leave the weighing dish open to facilitate weighing.

Tare the moisture teller pan with filter paper in the bottom and with the weighing dish without cover. Heat the pan and dish in the moisture teller and tare while hot. The use of filter paper in the drying pan does not retard the drying speed. It keeps the pan clean, and the filter paper can be repeatedly used if care is taken to shake it clean after each test.

Place the weighing dish containing the test sample in a heated drying pan with filter paper on the right pan of a balance, and balance to 50 grams of sand.

Dump the sand into the drying pan and leave weighing dish in the pan. Place in moisture teller or oven to dry. Having the moisture teller hot speeds the drying time so that a 3 min drying time as a rule is sufficient.

Re-weigh the dried sample by moving the rider of the lecture balance, and multiply the reading (weight loss in grams) by two to obtain the percentage of moisture. When a speed balance (Fig. 1) is used, the lower scale is read direct as percentage moisture to save time.

For sands above room temperature, one should use the actual moisture test procedure whenever total moisture reading is desired. This procedure is also advisable for moisture tests where accuracy is paramount, and sand is at or near room temperature, pro-

viding one wishes actual moisture content at the time of sand sampling.

Actual moisture percentage values express the total base and evaporation moisture contained in a sand at the time of sampling. It does not yield results that are easily applied in the foundry for tempering sand at the mixing station particularly where the sand temperature varies. Under such conditions, the actual moisture test readings would increase as the sand temperature increases, since a greater quantity of evaporation water is added at the mixer as the sand temperature increases.

It is much easier to use compensated moisture test readings that remain constant throughout the day when the sand is correctly tempered, as sand temperature varies. Thus, the compensated moisture test is of greater value for moisture control work in the foundry at the mixing station.

Compensated Moisture Test Method

Practically everyone is using the compensated moisture test method without giving it sufficient thought to yield accurate results. A better understanding of the compensated moisture test is necessary since it is a useful control tool. It is surprising how easy it is to apply correctly when care is exercised.

The sand sample is taken at the sand mill discharge and placed in a covered container. The simple operations are illustrated in Fig. 2. Quickly discard the top layer of warm or hot sand from container, mix by stirring with spatula and fill the weighing dish full of sand. Dump the sand from weighing dish into the drying pan with filter paper in bottom. Spread sand uniformly in the drying pan rapidly and immediately start weighing. The weighing dish places a little more than 50 grams of sand in the drying pan. Start a stopwatch and remove sufficient sand with a spatula to balance at 50 grams of sand when 60 sec time is reached.

During this first weighing operation, remove sand from the sand sample at one edge only. It is essential to present a constant sand sample contour to the atmosphere to obtain accurate results. Place the weighed drying pan containing the 50 grams of sand in the moisture teller and dry. Re-weigh and read moisture percentage from moisture percentage scale on the speed balance, or multiply rider reading by two when a lecture balance is used.

At the beginning of the test, use a hot pan and place a 5¼-in. diameter filter paper in the bottom of the drying pan. Thus, both weighing operations are made with hot pans so as to cancel out the greater part of the error of weighing with hot pans. The filter paper allows one to use a hot pan and to keep the pan clean. After each test, remove the filter paper and shake it clean for re-use.

USE OF MOISTURE TESTS

The 60 sec weighing time suggested in the compensated moisture test may not fit all sand systems. To find the correct weighing time, make an actual moisture test of the sand as it comes out of the molder's hopper. Then make a compensated moisture test of sand as it comes from sand mill discharge. Compare

Fig. 2 — Arrangement of equipment for compensated moisture test.

the actual moisture test reading at the molding stations with the compensated moisture test reading at the mixing station; both should be the same.

Alter the weighing time in the compensated moisture test to allow sufficient evaporation of moisture to yield compensated moisture test readings at the sand mill, which agree with the actual moisture test readings at the molder's hopper discharge.

Batches of sand which are discharged before being thoroughly mixed will cause erratic moisture percentage readings. Large variations in moisture percentages may be experienced without any exact pattern of error under such inadequate mixing procedure. Uniform moisture distribution must first be secured in the mill before one can apply strict moisture control.

Compensated and Actual Moisture Test Readings Comparison

Additional information on the subject is in the test data in Table 1. Here, for comparative purposes both the compensated and actual moisture tests were made on the same sand at the mixer discharge. Note that as sand temperature increases, the difference between the compensated and actual test readings increases. This illustrates that as sand temperature increases additional water is added to compensate for evaporation.

TABLE 1 – TEST DATA FOR ACTUAL AND COMPENSATED MOISTURE TESTS AT THE MIXER DISCHARGE AS SAND TEMPERATURE VARIES

Sand Temp., F	Compensated Moisture, %	Actual Moisture, %	Difference, %
66	4.95	4.87	0.08
76	5.1	5.04	0.06
88	4.95	5.03	0.08
93	5.0	5.14	0.14
100	4.9	5.1	0.20
105	4.82	5.08	0.26
107	4.8	5.07	0.27
108	4.95	5.3	0.35
116	4.75	5.22	0.47
126	5.1	5.65	0.56
129	5.0	5.86	0.86

Fig. 3 — Equipment for determining riddle density.

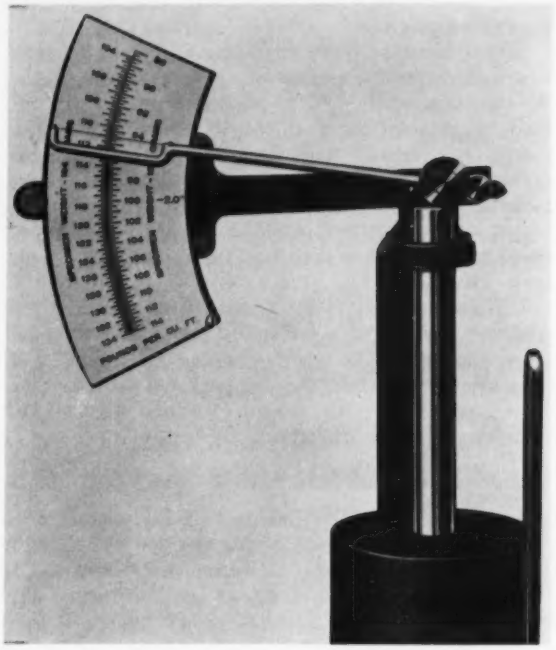

Fig. 5 — AFS Sand rammer with rammed density indicator.

Riddled Density vs. Moisture

Many prefer sand tempered so it is lightest in "feel." Some may not have given much credit to this method. The lightness of sand as affected by moisture, can be easily measured by determining the riddled density of a sand as moisture content is varied. The sand is riddled from a constant height into a container, with equipment shown in Fig. 3.

The sand container is filled with riddled sand and struck off level. The weight of the sand vs. moisture percentage yields a graph, as shown in Fig. 4. The weight of the sand is at a minimum in the temper moisture-percentage range.

The graph does not come to a sharp point at the minimum, so the precise moisture at temper is not shown. However, a useful moisture range yielding the lightest sand is shown.

An alternative method is to use an American Foundrymen's Society sand rammer with density indicator, Fig. 5. Ram the sand with three drops using a constant weight of sand, and vary the moisture. Read the rammed density from the density indicator. The object is not to obtain a sand with minimum density per se, but to moisten the clay substance which swells it to a good workability.

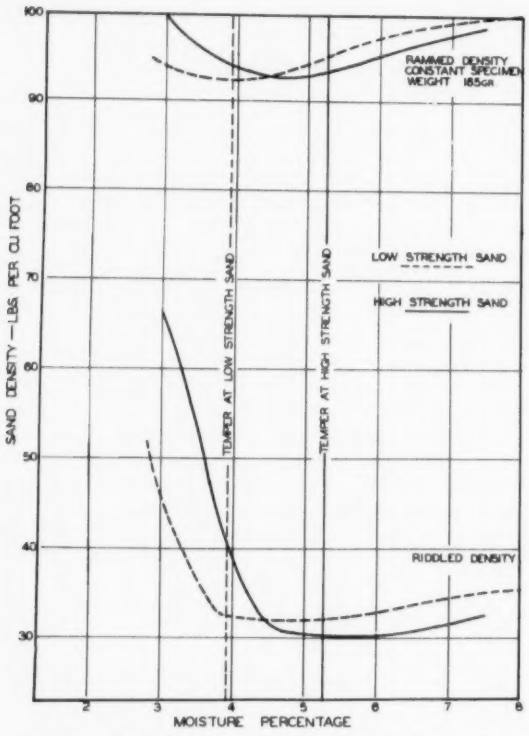

Fig. 4 — Riddled and rammed density vs. moisture content.

Ultimate Deformation as a Temper Control

Ultimate deformation measures the amount the sand specimen shortened at the time of failure under compressive load. Precisely, ultimate deformation is read at the point when the rate of specimen shortening exceeds the rate of load. The rupturing of the sand specimen is actually stretching the plastic bond in the sand to the breaking point. Moisture increases the stretching ability of the clay bond. Thus the ultimate deformation test reading is an index of the degree of wetting of the bond.

The ultimate deformation of a western bentonite bonded sand is linearly affected by the moisture content, as illustrated in Fig. 6.

The higher the moisture percentage, the greater the ultimate deformation. To make use of this rela-

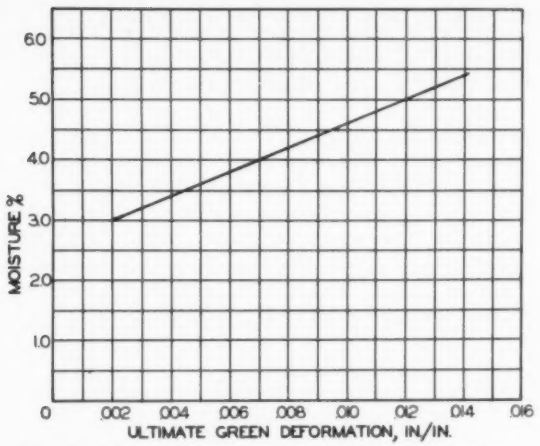

Fig. 6 — Relationship between ultimate deformation and moisture percentage.

tionship, it is necessary to determine the ultimate deformation as moisture is varied for a sand. Then temper the sand to the desired point found better in practice, and at this temper determine the ultimate deformation of the sand. For many sands other than steel, an ultimate deformation range between 0.016 in. - 0.020 in. is found ideal. Some southern bentonite bonded sands may perform better at a lower ultimate deformation, and deformation-moisture control may not be sensitive.

Thereafter, sufficient water is added to each batch of sand to cause sand to possess the predetermined ultimate deformation. Thus, the molders will receive a sand that has constant plasticity or workability, not a sand necessarily of constant moisture content.

Such a sand may actually form a mold of more constant properties than a constant moisture sand. A constant moisture sand, when a change in fineness or bond occurs, need not be at temper. Moisture content should be changed under such conditions to produce an ideally tempered sand of constant workability.

When ultimate deformation is the control index, then moisture content is changed to hold the plasticity of the sand constant. There are a few bonds, southern bentonite for example, where additional research work must be done to apply the ultimate deformation as a temper control.

Water, per se, is not a functional or a useful property that influences the workability of a sand. Thus, it may be found useful to use ultimate deformation as the temper control point for some sand. A sand in a system may not remain constant in fineness, bond, facing or cellulose material content, etc. As these items vary, and the sand is tempered to a constant ultimate deformation, the molders may not notice as much difference in the sand as compared to sand that is tempered to a constant percentage of moisture.

TEMPERING TO ULTIMATE DEFORMATION

The usefulness of tempering sand to a predetermined ultimate deformation reading can be demonstrated by tempering both a normally low-strength

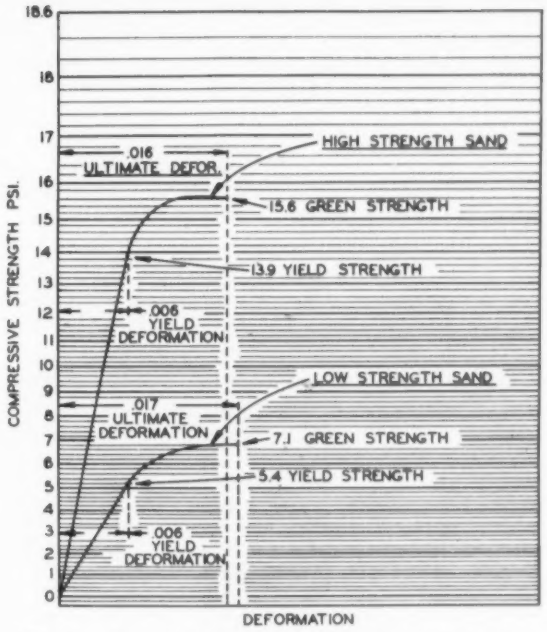

Fig. 7 — Stress-strain curves for 7.1 psi and 15.6 psi strength sands.

sand, for example 7.1 psi, and a high-strength sand, for example 15.6 psi, to good workability.

Assume that a low-strength sand was in use, and workability was found satisfactory. A high-strength sand was desired to obtain better casting contour accuracy and still retain the good workability of the low-strength sand. There are two ways available to temper the high-strength sand, one of which would be to add sufficient moisture by trial and error method to secure good flowability and rammability.

However, a more direct avenue is open. Add sufficient water to the high-strength sand mix to produce an ultimate deformation that is the same as that of the good low-strength molding sand. Using this procedure, one secures stress-strain curves, as shown in Fig. 7. The ultimate deformation of the low-strength sand is 0.017 in., and for the high strength sand it is 0.016 in. The actual moisture percentage of the low-strength sand is 3.95 per cent, and for the high-strength sand is found to be 5.2 per cent. Thus, the correct temper for the high strength sand at room temperature is 5.2 per cent actual moisture, and at elevated temperature it is 5.2 per cent compensated moisture.

Since good flowability is essential in the production of high quality castings, an examination of the flowability is in order for these reference sands. Figure 8 shows both the low and high-strength Rowell flowability specimens of the low- and high-strength sands. The specimens are similar in appearance, showing no excessive false voids.

Test castings were made in type metal with both of the sands, shown in Fig. 9. The castings made in the high-strength sand show less metal penetration than castings made in the low-strength sands. The strength of a sand does affect in some manner the degree of

metal penetration. The reason for this is not known.

The amount of sand burn-in in grams is shown in Table 2 as 28.8 grams for the low-strength sand, and 1.2 grams for the high-strength sand. The high-strength sand produced a casting with better finish than the low-strength sand.

The Rowell flowability test showed that high-strength sand had better flowability, which agrees with test casting results.

The creep deformation of the low-strength sand under a 5 psi load is 0.0053 in., and 0.00187 in. for the high-strength sand. Figure 10 shows the creep deformation curve for these two sands. The high-strength sand has only one-third as much creep as the low-strength sand. This means that molds made from the high-strength sand would have much less mold wall movement, producing castings more accurate in contour.

Therefore, castings made in the high-strength sand will weigh less than those made in the low-strength sand. Referring to the test data in Table 2, it is found that the type metal test castings made in the high-strength sand weigh on the average 778.8 grams, while castings made in the low-strength sand weigh on the average 789.4 grams.

Sand specimens made with the high-strength sand

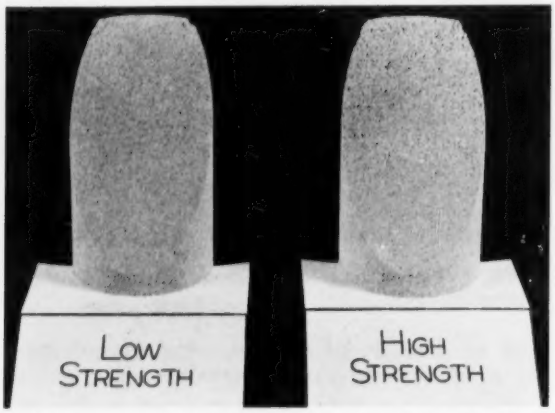

Fig. 8 — Visual flowability of the 7.1 psi and 15.6 psi strength sands.

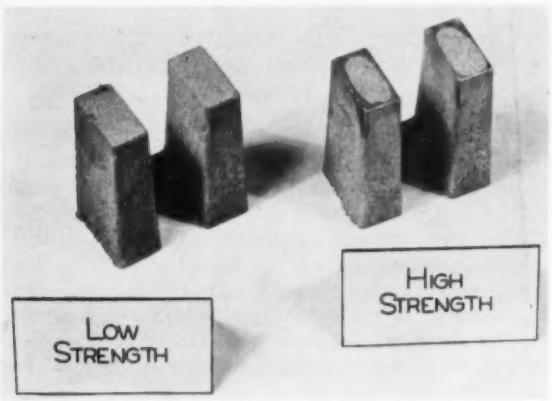

Fig. 9 — Type metal test castings of the 7.1 psi and 15.6 psi strength sands.

TABLE 2 – SAND PROPERTIES FOR 7.1 PSI AND 15.6 PSI STRENGTH SANDS TEMPERED TO SAME ULTIMATE DEFORMATION

Property	Low Strength Sand	High Strength Sand
Mix: Bank Sand %	93.0	89.0
Western bentonite, %	7.0	11.0
Moisture, %	3.95	5.2
Rammed density, lb/cu ft	95.55	92.7
Riddled density, grams/qt.	598.10	579.5
2 in. x 2 in. specimen weight, grams	153.0	154.1
Green permeability	88.6	85.8
Green compression, psi	7.1	15.6
Ultimate green Deformation, in./in.	0.017	0.016
Yield strength, psi	5.3	13.9
Yield deformation, in./in.	0.0065	0.0065
Mold hardness, top	88	91
Mold hardness, bottom	87	90
Indicator flowability, %	82	70
Rowell flowability, %	84	87
Dry compression, psi	148.7	145.0
Air set strength, psi	30.2	32.5
Creep deformation, 5 psi load, 1 min, in./in.	0.00530	0.00187
Expansion, 1 psi load, 1800 F, 22.5 sec, in./in.	0.0067	0.0054
Restrained load, 1800 F, 30 sec, psi	68	59
Hot strength at: 500 F, psi	174	190
1000 F, psi	223	236
1500 F, psi	547	677
2000 F, psi	198	268
2500 F, psi	4	4
Hot deformation at: 500 F, in./in.	0.0085	0.0098
1000 F, in./in.	0.0092	0.0126
1500 F, in./in.	0.0148	0.0190
2000 F, in./in.	0.0983	0.1198
2500 F, in./in.	Plastic	Plastic
Sand burn-in weight, gram	28.8	1.2
Casting weight, gram	789.4	778.8

showed a top mold hardness of 91 as compared to 88 for the low-strength sand. This illustrates the fact that high mold hardness may be obtained with high-strength sands when they are correctly tempered by the ultimate deformation method.

The dry strength and the air-set strength properties are similar for the low- and high-strength sands when they are tempered to the same ultimate deformation, as shown in Table 2.

Mold wall fracture casting losses, such as scabs, rat-tails and buckles, are directly related to the restraining load and the 1 psi load expansion test at 1800 F.* The high-strength sand has a lower restraining load and a lower 1 psi load expansion than the low strength sand, indicating that one should experience less scabbing, etc., with the high-strength sand. However, both of these test values are too high for a safe sand, thus scabbing losses may be expected with either sand. The addition of a carbonaceous, cellulose or cereal material will lower the restraining load below the 50 psi danger limit for either sand.

The hot strengths of the low and high-strength sands are identical for all practical purposes and are conservative. The high-strength sand has a slightly better hot deformation, which agrees with the slightly better restraining load and 1 psi load expansion test results.

*AFS Transactions, *vol.* 65, 1957, pp. 128-133, and 235-237.

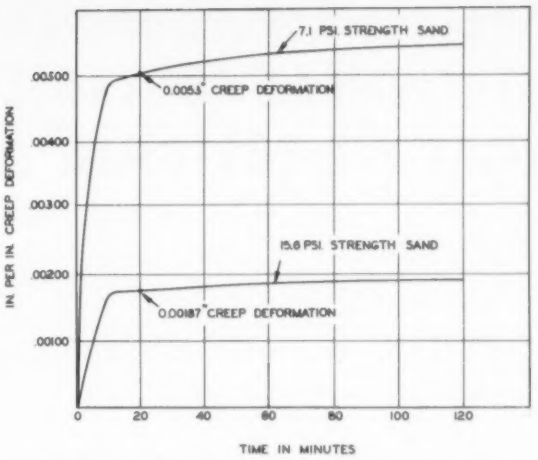

Fig. 10 — Creep deformation curves of 7.1 psi and 15.6 psi strength sands.

CONCLUSIONS

1. When tempering sand, water must be added for base water and evaporation water requirements. The base water plasticizes the bond and moistens the sand grains. Evaporation water is lost during the sand handling.
2. The actual moisture test procedure should be used whenever the total percentage of moisture in a sand is desired, as it measures both the base water and evaporation water.
3. The compensated moisture test procedure, which yields the moisture percentage consisting largely of only base water, is used for moisture control work at the mixing station.
4. The actual moisture test procedure is used when determining the moisture of the sand at the molding station, in research work or when determining the total water added to a sand.
5. The compensated moisture test procedure is used when determining the moisture at the mixing station. It is the moisture control test that anticipates the moisture of a sand after it arrives at the molding station.
6. Test procedures of the actual and compensated moisture test must be followed carefully to obtain reliable results.
7. Test equipment used in moisture tests must be maintained in excellent working order.
8. Uniformity of sand is essential in applying moisture control by the moisture testing methods.
9. The old time expression of tempering a sand to "feel" lightest is a technical fact.
10. Tempering sand to a constant compensated moisture content is in everyday use. However, it need not be considered the ultimate in sand control. Constant compensated moisture control does not yield the better tempered sand in reference to workability when the sand in the system varies in bond, fineness or in other ingredients. Such sands may have a better workability if sufficient water was added to cause a constant ultimate deformation.
11. A high-strength sand may be tempered to the better workability by using ultimate deformation as the means of determining temper point.
12. A high-strength sand controlled at a constant ultimate deformation will produce castings of better contour, less weight, less penetration and less mold wall fracture losses than a low-strength sand, and with equal molding ease.

SPECIALIZED FOUNDRY STATISTICAL CONTROLS IMPROVE CUSTOMER SATISFACTION

By Buford M. Appleman

ABSTRACT

The major statistical process and job quality controls which have been developed especially for foundry applications at the author's company are described. The $\overline{X}$ and R Charts are not discussed in this paper because many previous articles have been devoted to them.

Techniques presented herein are based on sound statistical relationships, and wherever possible they are applied in simplified "cookbook" form to facilitate line usage right in the foundry by foundry personnel.

Customer satisfaction is, of course, the main objective. However, in order to achieve this goal operational economics must be practical. For this reason the management of the quality control activity is critical. Special techniques are presented which simplify much of the judgment as to the location and amount of effort expended.

The development and installation of this total quality control program has been instrumental in reducing total hard and soft iron scrap from a 27-month average of 10.9 per cent, to a full year of experience at 5.4 per cent with still further gains anticipated. Based on $150 per ton average hard and soft iron scrap, this savings has been worth some $80,000 during the past year. Incidentally, this was done in a jobbing shop, and surprisingly was accomplished by lower quality control man-hours per ton and reduced customer returns.

INTRODUCTION

Manufacturing plants previously accepted the cross of Inspection departments, but with the advent of mass-production machines and munitions manufacturing this activity was re-evaluated. It was not feasible to blow up each shell to see if it was all right before it left the assembly plant. However, in mass production 100 per cent inspection activity sometimes costs as much as the production of the items itself. At this point sampling plans came into vogue along with $\overline{X}$ and R Charts. Both techniques were designed primarily for mass production and machine shops. Naturally, other industries picked up these techniques and adopted them with varying degrees of success. When this was done, they promptly felt that they had installed statistical quality control programs.

In the foundry business these sampling plans and $\overline{X}$ and R Charts are good tools but they leave much to be desired. They do not answer the question of which jobs or processes should be controlled, where to control averages or how much variability is to be allowed. Foundries desire to manufacture quality into the product, which is the basis for the $\overline{X}$ and R concept. However, this is much easier said than done. The gray and malleable iron foundries find this to be particularly true because the casting is either good or bad when it comes out of the sand, and it is too late for much salvage action. It can either be shipped or scrapped. Steel foundries can salvage castings by welding, but this, too, costs money.

Foundry problems are tough and they are a challenge – perhaps that is why so many keep fighting – they just hate to give up. Seriously, foundry problems are just as difficult as those encountered by the petroleum and chemical plants. The main difference is that most foundry units are fractional in size as compared to petrochemical plants, which can afford large engineering staffs and have been progressive in developing special statistical quality control techniques and experimental designs. Perhaps foundries can not go as far as the process industries have gone, but it is possible to incorporate successfully many of their techniques.

The American Society for Quality Control is doing much to foster this type of work, which can be of invaluable assistance to foundries through local chapters and special groups.

CASTING BUYERS WANT IMPROVED QUALITY

Foundrymen realize and feel the pressures for upgrading quality being brought upon them by casting buyers. What are the reasons for this? An analysis of factors which contribute to customer satisfaction includes the following:

The lowest per cent defective is highly desirable. Machine tools are expensive, and are of a higher production type than before. Skilled and semi-skilled labor is costing more money all the time. Tooling and setup costs are more expensive on these more complex machines. Inspection is more critical and assemblies more complex.

Closer tolerances are desired. Less machining is required if casting tolerances are held more closely. This results in a better fit of rough castings in assemblies, and also simplifies the assembly itself. Less total movement in chucks of highly mechanized machinery allows less variability of raw castings than the

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three and four jaw hand-tightened chucks of the past.

Most exacting quantities of delivery keep inventories in balance. Money tied up in inventories is expensive for both the foundry and customer. To maintain a minimum inventory requires more exact predictions of per cent scrap at the foundry or the foundry is forced to ship short and disappoint the customer, or hold the overage of customer's castings in inventory until receipt of additional orders as the past few years have brought evidence of customer reluctance to accept the usually permissible 10 per cent over or under shipment.

Shorter deliveries reduce inventories. Shorter deliveries also reduce investment but these shorter delivery commitments do not allow time for trial-and-error production.

These factors are wanted at lower casting costs to the casting buyer. If it were possible to snap one's fingers and improve quality levels and produce more consistent castings, it would be done because customer satisfaction would increase and foundry costs would decrease.

Many advantages accrue to the foundry with better quality control. Better quality control offers many intangible advantages to the foundry. High quality castings will result in sale of more tons by virtue of their perfection alone. Salesmen are more efficient when they have fewer complaints, and are received more readily in customers' engineering, manufacturing and purchasing departments.

The tangible advantages in better quality control are many. They include lower inspection costs on the final product by acceptance sampling of more lots. There is less rework and salvage as well as fewer returns from the customer. Lower charge-backs for loss of machine time and tools or inspection are a direct result. Lower scrap is significant in calculating the value of better quality control. Fewer customer complaints and service calls are necessary when such a condition does exist, because 100 per cent inspection is seldom as efficient as manufacturing quality into the product.

There is an optimum amount of money which can be spent to achieve better control. The cost of such a program must be repaid by savings accrued through the program. Money can be invested only until the economical balance of total actual dollars of scrap, salvage, charge-backs, returns and inspection labor has reached the optimum from which any change would result in higher total cost of all quality factors. This approach to optimum is the real contribution quality control makes toward quality, delivery, cost or the total financial gain of the business enterprise.

SCRAP HISTORY

The scrap history for 2¼ years in the Malleable Div. of the author's company is shown in Fig. 1. This average was 10.9 per cent. A dollar value was calculated for this scrap at the minimum variable cost rate of $150 per ton total hard and soft iron scrap. At the volume level during this period the value of one per cent scrap was estimated at $15,000 per year. It was felt that some of this total scrap could be eliminated economically. How much could be eliminated and at what cost?

Analysis of this scrap indicated that 15 per cent of the jobs resulted in two-thirds of the total quality loss (Fig. 2). This supported the Pareto principle. Pareto was an Italian economist who discovered that approximately 2 or 3 per cent of the Italian population controlled over 95 per cent of the wealth of the country. In applying the same principle to the amount of crops produced from certain farm areas, he found the same condition existed in that a few acres usually produced most of the crop. There were many other applications in which the same principle applied. His theory was that only a few factors of a large number contribute most of the goodness or badness of the product.

Next it was assumed that a reduction of the scrap losses in the 15 per cent of the jobs producing most of the scrap could be made. Such reduction, estimated at 50 per cent, would result in at least 25 per cent reduction of the total quality loss, and it was believed attainable within one year. This means a goal of 8.2 per cent which would result in savings in excess of $40,000.

Top management recognized that such a program indicated a favorable return on its investment. This factor, plus the awareness of general quality upgrading by casting buyers, resulted in 100 per cent backing of the program by top management. Such an attitude must be vividly apparent to all production personnel if a program of this nature is to succeed.

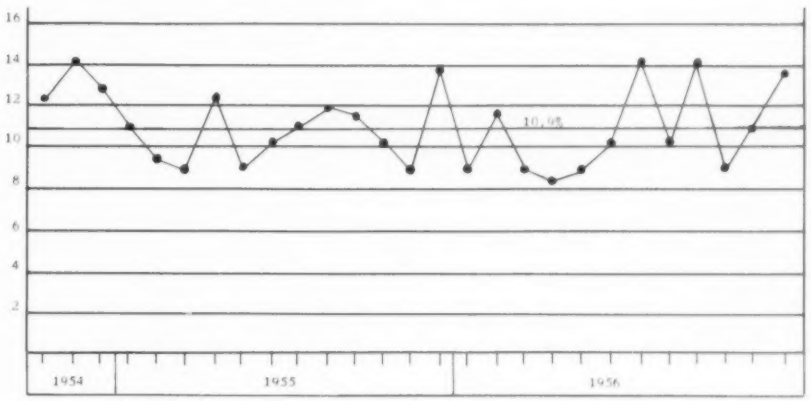

Fig. 1 — Total malleable division hard and soft iron scrap, October, 1954 through December, 1956.

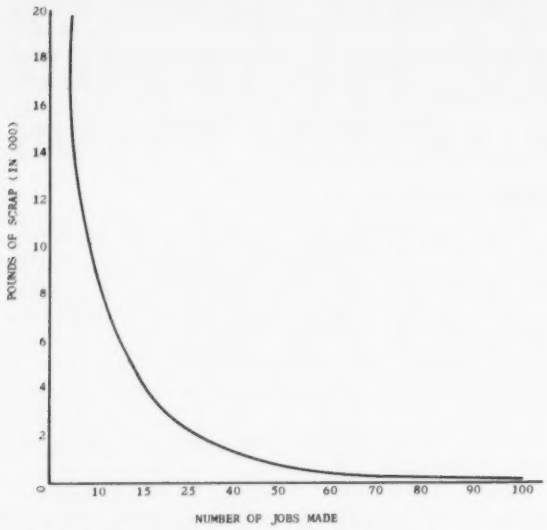

Fig. 2 — The Pareto curve indicates that a small percentage of the jobs run result in a large percentage of the total scrap. Graph shows weekly average malleable scrap, scrap pounds vs. number of jobs made.

THE PROBLEM

Foundries have a severe quality problem due to the fact that a large transformation takes place from melting of raw materials through the liquid pouring of metal into green sand molds around dry sand cores to solidification in the molds shaped by a pattern.

The problem at the author's company was basically this. A job would run two or three times quite well, and then the next time the scrap loss would be heavy. Sometimes this would not show up until after anneal, which is 10 days or so after the job is made in the molding sand. Another phase of this problem is that a defect might be caused by several things. A swell or an enlarged portion of the casting might be caused by:

1) A soft mold due to insufficient jolting or squeezing.
2) A ram-away caused by the machine jolting off center or the pattern being offset.
3) Bad flask due to warpage, etc.
4) Bad jacket or jacket set on the mold incorrectly.
5) Weak sand lacking in green or hot strength.
6) Partially burned out bottom boards.

A hot crack or shrink might be caused by:

1) Soft molding.
2) Hard molding.
3) Pouring at too slow or too fast a speed.
4) Metal temperature might be too hot or too cold.
5) Dumping the mold too hot and not allowing sufficient cooling.
6) Metallurgical or sand conditions being such that this defect will occur.
7) Gating itself might not be quite safe enough to take care of the normal variation for which allowance must be made.

Few of the causes of defects can be analyzed accurately after the castings are made, poured, dumped, cooled, sprued and cleaned, because all of the evidence is gone. If the quantity is small, and the job ordered only periodically such as two or three times per year, the problem is exaggerated.

THE QUALITY IMPROVEMENT PROGRAM

A self-analysis was made to determine the basic problems. Because of the difficulties, as pointed out in previous paragraphs, it was found that often the pattern itself was changed in order to produce better castings. Sometimes this was done when the same pattern had been used previously in a production run of high quality castings. Obviously, this was being done in many cases because of the variability of some other phase of the manufacture, and should not have been necessary in the first place. Of all the factors which can change from one run to the next, the pattern should change the least.

By the the same token, it was known that purposeful changes in carbon, tap-out temperature, moisture content, green strengths, etc., had been made in the shop with the belief that such action would cure some defect which seemed to be rampant. Sometimes many changes were made almost simultaneously. If an improvement did occur, the real reason for it was not always known. It might have been some factor not considered at all, which was varying or that particular group of jobs showing improvement, might have been different from those which suggested the need for a change.

BASIC CORRECTIVE STEPS

Consistency was sought by resisting changes in basic operational methods without careful analysis of the defects and their real importance from a dollar and quality standpoint.

Process control was brought in, and at the same time a consulting engineering firm was retained to assist in the design and evaluation of statistical experiments and training of foundry personnel in these techniques. The largest of these experiments was designed to determine which of seven elements each of sand and metal, plus pouring time and dumping time, were critical from a quality standpoint. Emphasis was placed on solving hot cracking and shrinking tendencies.

This experiment included five patterns representing various types of jobs run at this shop. Some of these were the "stinkers" which was the name given those jobs producing two-thirds of the scrap. This experiment was known as project RAFE (Random Assignment Factorial Experiment). Figure 3 shows the experimental design; the plus (+) and minus (−) indicate levels of each. This experiment took over two weeks to design, two weeks to run and over four weeks to evaluate its major findings. As a result only four major changes were recommended.

1) Pour the metal colder than 2850 F at the tap out.
2) Avoid excessive fines (limit to 5 per cent maximum fines).
3) Control moisture in the sand at a level just sufficient for tempering.

4) Use more than 4.0-5.0 per cent sea coal in the sand.

These were then adopted and operational controls were adjusted to the new balance. $\overline{X}$ and R type of controls are now used to maintain control on some of these critical items, and several other controls were eliminated as being unimportant. It should be emphasized that findings are helpful to the author's company, but this does not necessarily mean that they will help any other malleable shop because of the difference in each foundry of castings run, gating systems, melting practice, sand control, etc.

Tools for Job Control Were Developed

Job control in foundry production does not lend itself to simple single sampling plans, because the

PROJECT RAFE

		PLATE	PIG	OXIDATION	CARBON	SILICON	ALUMINUM	TEMPERATURE	SAND	MOISTURE	SEA COAL	CLAY	MOLD PRESSURE	BENTONITE	CEREAL	POURING RATE	DUMPING TIME	
VARIABLE		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
DAY	RUN																	
1	1	+	+	-	-	-	+	+	-	-	+	+	-	+	+	+	-	
1	2	+	+	-	-	-	+	-	-	+	-	-	+	-	-	+	+	
1	3	+	+	-	+	-	-	+	+	-	+	+	-	-	-	-	+	
1	4	+	+	-	+	+	-	-	-	-	-	+	+	-	+	+	+	
2	5	-	+	-	+	+	+	+	-	-	-	-	+	+	+	-	-	
2	6	-	+	-	+	-	+	-	+	+	-	-	-	+	-	+	-	
2	7	-	+	-	-	-	-	-	-	-	+	-	+	-	-	-	+	
2	8	-	+	-	-	+	-	+	+	-	-	+	-	+	+	-	+	
3	9	-	-	-	-	+	+	-	-	-	-	+	-	+	-	-	-	
3	10	-	-	-	-	-	+	+	-	+	+	-	-	+	-	+	+	
3	11	-	-	-	+	-	-	+	-	-	-	+	-	-	-	-	+	
3	12	-	-	-	+	+	-	-	+	+	+	+	-	+	+	-	-	
4	13	-	+	+	+	+	-	-	+	-	-	+	+	+	-	-	-	
4	14	-	+	+	+	-	-	+	+	+	+	-	+	-	-	+	+	
4	15	-	+	+	-	-	+	+	+	+	+	-	-	-	+	-	-	
4	16	-	+	+	-	+	+	-	-	+	-	+	+	+	-	-	-	
5	17	+	-	-	-	-	-	-	+	-	+	-	+	+	+	-	-	
5	18	+	-	-	-	+	-	+	+	+	-	+	+	-	+	+	-	
5	19	+	-	-	+	+	+	+	-	+	-	+	-	+	+	+	-	
5	20	+	-	-	+	-	+	-	+	+	+	+	+	+	-	-	+	
6	21	-	-	+	+	-	+	-	-	-	+	-	-	-	+	-	+	
6	22	-	-	+	+	+	+	+	+	+	-	+	-	-	-	+	-	
6	23	-	-	+	-	+	-	+	-	+	+	-	+	+	+	-	+	
6	24	-	-	+	-	-	-	-	-	-	+	+	+	+	-	-	-	
7	25	+	-	+	-	+	+	-	+	-	+	-	-	+	-	-	+	
7	26	+	-	+	-	-	+	+	+	-	-	-	-	-	+	+	+	
7	27	+	-	+	+	-	-	+	+	-	-	-	+	-	-	+	+	
7	28	+	-	+	+	+	-	-	-	+	+	+	-	-	-	+	-	
8	29	+	+	+	+	+	+	+	+	-	+	+	+	-	+	+	+	
8	30	+	+	+	+	-	+	-	-	+	+	+	+	-	+	+	+	
8	31	+	+	+	-	-	-	-	-	+	-	-	-	-	+	+	-	
8	32	+	+	+	-	+	-	+	+	+	-	-	+	+	+	+	-	

Fig. 3 — Project RAFE was designed to determine which of seven elements of metal, plus pouring rate and dumping time made the highest quality castings.

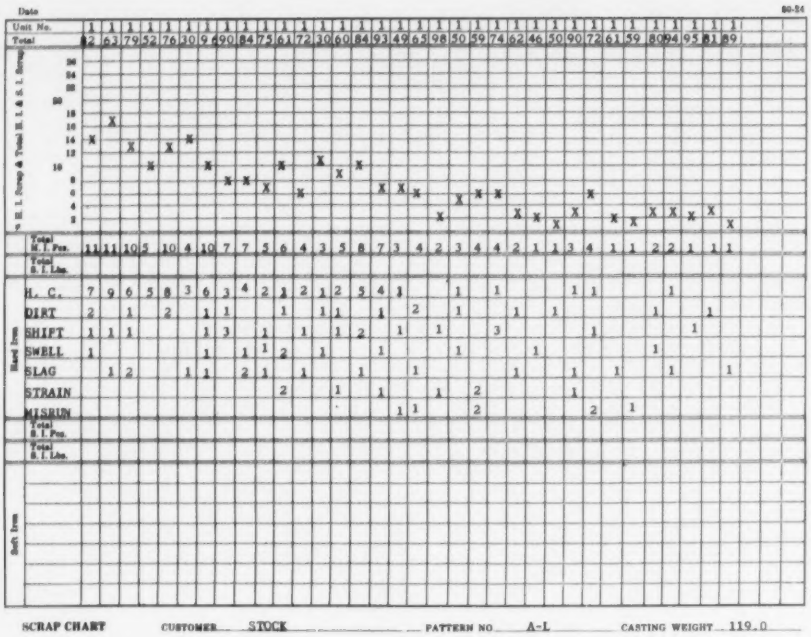

Fig. 4 — Job history of a "stinker."

entire production run is not complete at the time the decision of run or stop must be made. For this reason signals were necessary to decide which jobs would be controlled during production.

"Stinkers" were defined as those jobs having 500 lb or more of scrap in one week. Figure 4 shows the history of a stinker. The original concept of 5 per cent maximum scrap per job was not good. The trouble with this approach was that if a small order was run at 25 per cent scrap, it might take as much quality control and production supervision time for control as would be required to reduce from 5 to 4 per cent a comparatively large production item with much greater total scrap reduction.

One example of this was the permanent mold production of tee-head bolts. Since production was over 50,000 pieces per week, it was worth while to reduce scrap appreciably. It now runs at less than 1½ per cent under normal conditions. This also results in a savings of hard iron and soft iron inspection labor which is very significant.

Sequential Charts

Sequential charts like the one in Fig. 5 were designed for the control of stinkers, and they were set to the wishes of management regarding acceptable and unacceptable limits. If the line enters "Question Continuation of Operation," the odds are that nine times out of ten the job is running worse than 12 per cent. By the same token there is only one chance in 20 that a job going below the lower line with inspection stopped will be worse than 2 per cent.

All stinkers are watched daily by quality control and production supervision. Sequential charts are

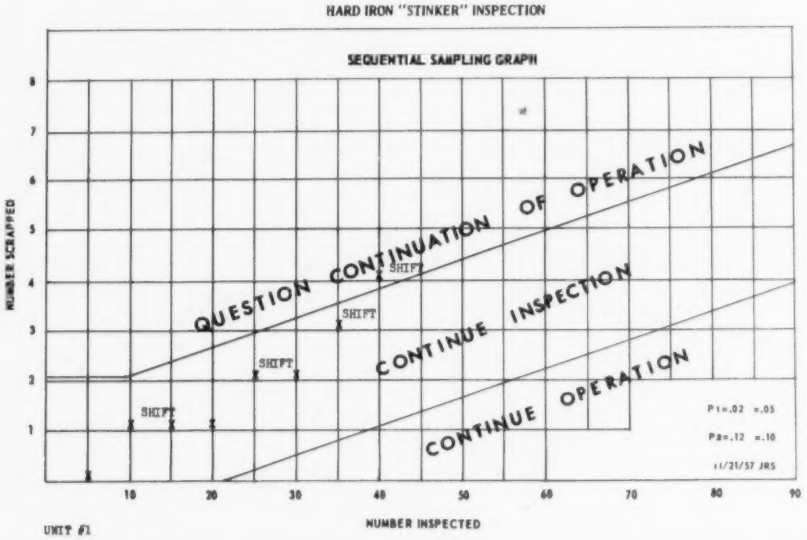

Fig. 5 — "Stinker" sequential chart shows job going out of control.

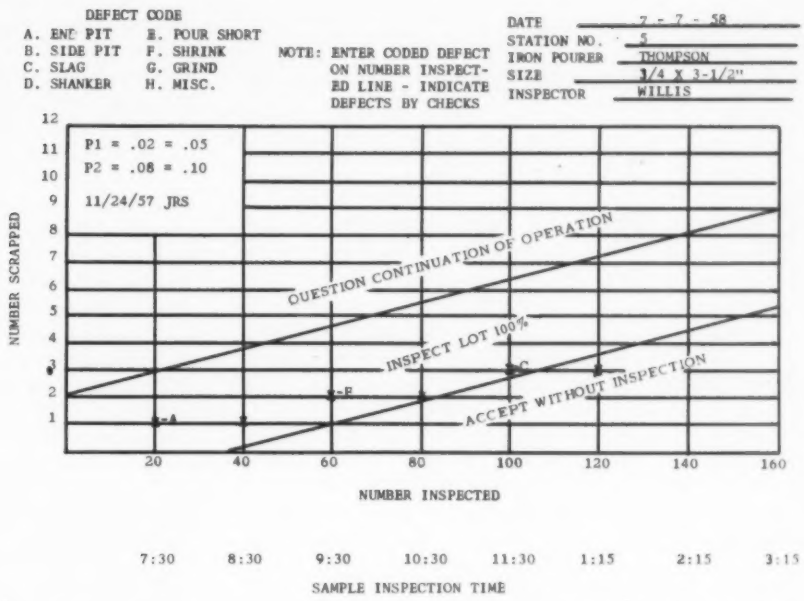

Fig. 6 — Sequential chart on ¾-in. T-Head bolt shown entering "Accept Without Inspection" area.

used to chart job progress each day, and if a stinker is running good enough to enter the "Question Continuation of Inspection" area three production days in a row, even if separated by 6 months between each day of production, it is dropped from the stinker list. If it goes out of control into "Question Continuation of Operation," the job is immediately stopped, or else multi-vari data are accumulated and then it is stopped. If the job stays in the middle of the band, inspection is continued. These charts are revised as total scrap is lowered. The bolt chart is far tighter than the regular stinker chart, as shown in Fig. 6. These charts can be designed for any desired level of acceptance of rejection.

New job control falls into the same category and a new job is guilty of being a stinker until proven innocent.

Reporting Systems

Reporting systems determine the location and magnitude of dollars of quality loss. Table 1 shows the malleable division weekly report. Units, classes, and defects are fairly good, but there are stinkers. Again, the Pareto curve is used in this analysis to point out the major area of defect by dollar loss. The clerical efforts of the entire quality control team are most efficient when tackling the largest item which is out of control.

The reporting system tells whether one of the molding units, certain of the defects by class of defect, a particular class of casting, or a few individual pattern numbers seem to be out of control. The Pareto principle says there will be one of these out of control, and so far there has been. When this is no longer true, then it is obvious that further reductions will be uneconomical.

The scrap goal is not zero and efforts are made to state carefully that the goal is always the economic optimum. This is true because the lower the per cent scrap, the harder it is to push it still lower, and the more effort is required to maintain that level. This is a dynamic system and efforts must be constantly shuffled around to achieve the greatest gain for the least expenditure of time and effort.

Special Problem Solving Techniques

One of the special problem solving techniques used when a job goes out of control on the sequential chart

TABLE 1 — MALLEABLE DIV. HARD IRON SCRAP SUMMARY
AUG. 19 - AUG. 22, 1957

Unit	Scrap, lb	Produced, lb	Scrap & Good, % True
1	3,532	24,985	14
2	735	13,323	6
3 & 4	1,280	33,442	4
5B & 5C	511	21,900	2
5A-7 & 8	5,179	74,181	7
6	6,141	112,688	5
S.F.	650	2,644	25
Samples		14,009	
H.I. break	909		
Total	18,937	280,003	6.8

Class	Scrap, lb		Defect	Scrap, lb	
Chunky	5,059	27%	Hot crack	3,744	20%
Ring	2,895	15	Dirt	3,096	16
Brake shoe	2,793	15	Shift	2,293	12
Pipe fitting	1,677	9	Swell	1,908	11
Hub	1,141	6	Misrun	1,464	8
Spool	970	5	Slag	1,010	5
H.I. break	909	5	H.I. break	909	5
Spoke wheel	696	3	Draw	852	4
Misc.	2,797	15	Pour short	773	4
			Strain	631	3
			Misc.	2,257	12
Total	18,937			18,937	

Hard Iron Stinkers

Customer	Pattern no.	Scrap, lb	Scrap, %
A	606-2453	3,330	18
B	UB 1177	2,899	15
C	2A-167	1,127	6
D	PP 5172-5	734	4
E	1366	696	3
F	UB 1002	639	3

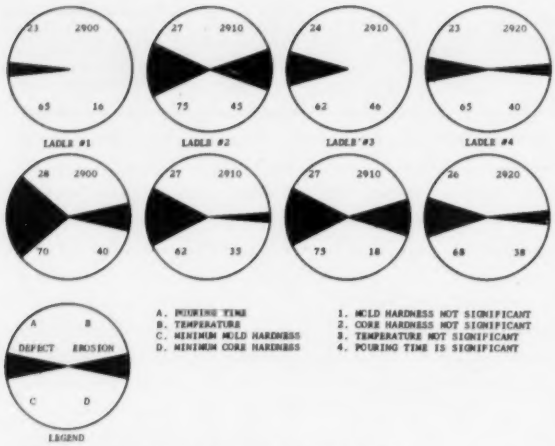

Fig. 7 — Typical Multi-Vari Data Chart.

involves the accumulation of data. There are many variables which can interact and cause scrap castings just by their own variability. The variables such as sand temperature, moisture control, green and hot strength, mold hardness, pouring time, pouring temperature, pouring technique, dumping times, etc., are all constantly changing within certain limits. To assume that each one will stay exactly where it was while making two or three molds is unrealistic. There is still a lot of "art" necessary in this business, but castings do react to certain scientific rules and patterns.

The problem is to determine what the ground rules are for good production of each job and then each process. The accumulation of multi-vari data is for the purpose of determining these rules. Figure 7 is only one of many different types of multi-vari charts. Multi-vari data include numbering within a mold, and each mold is numbered in sequence. All variable information known to be of common importance is accumulated during that time. This includes core hardness, mold hardness, pouring time, pouring temperature, pouring technique, jacket sequence, etc.

Analysis of the type and severity of the defects against the multi-vari data will show a pattern. The time cycle of the magnitude of the defect will answer questions as to the basic problem area. Figure 8 illustrates another type multi-vari chart.

The questions are these. Is it a matter of position within a mold that pattern 1 is consistently better or worse than another? Is there any period of time within the manufacture of the castings when the quality level seems to change? Is it that one ladle of iron is better than another? Is it that fast pouring of hot metal results in better castings than does slow pouring of cold metal? Or is it any other combination of factors? Pareto principles again say that a few factors make the job right or wrong. These clues will point out the variable area that must be controlled, and where that variable must be controlled to give quality in subsequent production.

Such a procedure minimizes the chances of making two or three good castings after a change and releasing a job which might still have heavy scrap. It is possible to roll a pair of dice twice and have "snake eyes" both times, but if we can see only the tops of

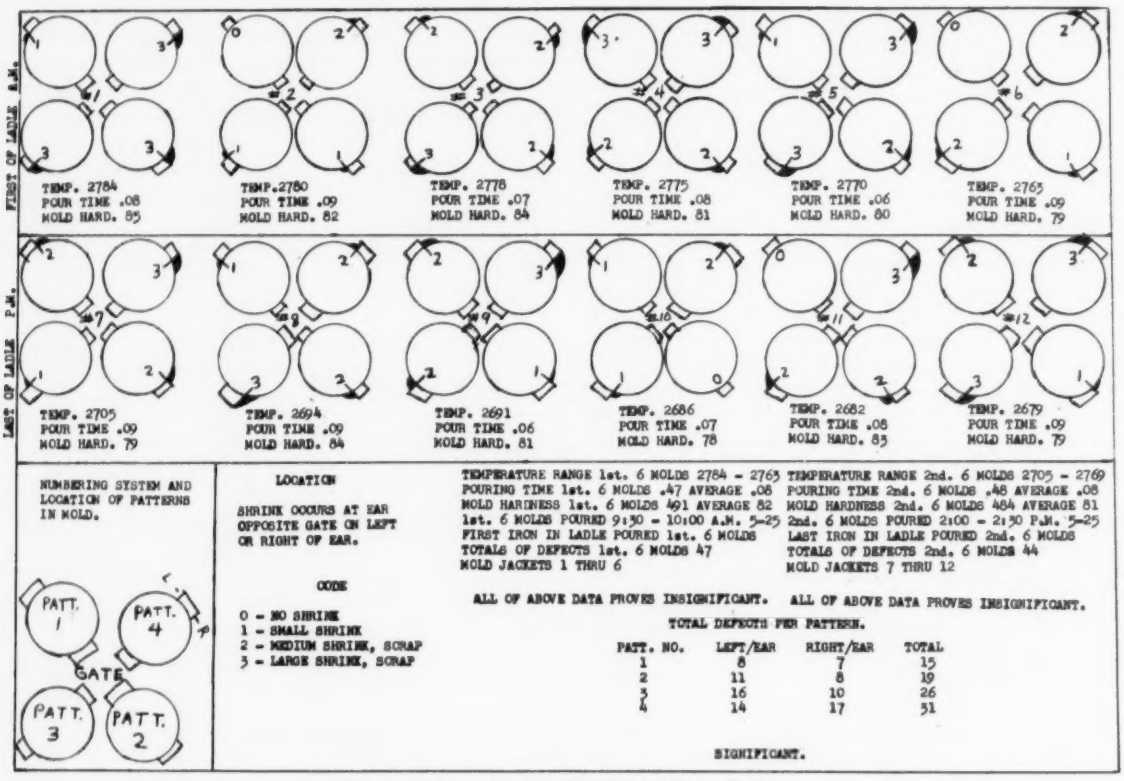
FIRST OF LADLE A.M.
LAST OF LADLE P.M.
TEMP. 2784 POUR TIME .08 MOLD HARD. 85
TEMP.2780 POUR TIME .09 MOLD HARD. 82
TEMP. 2776 POUR TIME .07 MOLD HARD. 84
TEMP. 2775 POUR TIME .08 MOLD HARD. 81
TEMP. 2770 POUR TIME .06 MOLD HARD. 80
TEMP. 2765 POUR TIME .09 MOLD HARD. 79
TEMP. 2705 POUR TIME .09 MOLD HARD. 79
TEMP. 2694 POUR TIME .09 MOLD HARD. 84
TEMP. 2691 POUR TIME .06 MOLD HARD. 81
TEMP. 2686 POUR TIME .07 MOLD HARD. 78
TEMP. 2682 POUR TIME .08 MOLD HARD. 85
TEMP. 2679 POUR TIME .09 MOLD HARD. 79
NUMBERING SYSTEM AND LOCATION OF PATTERNS IN MOLD.
PATT. 1
PATT. 4
GATE
PATT. 3
PATT. 2
LOCATION
SHRINK OCCURS AT EAR OPPOSITE GATE ON LEFT OR RIGHT OF EAR.
CODE
0 - NO SHRINK
1 - SMALL SHRINK
2 - MEDIUM SHRINK, SCRAP
3 - LARGE SHRINK, SCRAP
TEMPERATURE RANGE 1st. 6 MOLDS 2784 - 2765
POURING TIME 1st. 6 MOLDS .47 AVERAGE .08
MOLD HARINESS 1st. 6 MOLDS 491 AVERAGE 82
1st. 6 MOLDS POURED 9:30 - 10:00 A.M. 5-25
FIRST IRON IN LADLE POURED 1st. 6 MOLDS
TOTALS OF DEFECTS 1st. 6 MOLDS 47
MOLD JACKETS 1 THRU 6
TEMPERATURE RANGE 2nd. 6 MOLDS 2705 - 2769
POURING TIME 2nd. 6 MOLDS .48 AVERAGE .08
MOLD HARDNESS 2nd. 6 MOLDS 484 AVERAGE 81
2nd. 6 MOLDS POURED 2:00 - 2:30 P.M. 5-25
LAST IRON IN LADLE POURED 2nd. 6 MOLDS
TOTALS OF DEFECTS 2nd. 6 MOLDS 44
MOLD JACKETS 7 THRU 12
ALL OF ABOVE DATA PROVES INSIGNIFICANT.
ALL OF ABOVE DATA PROVES INSIGNIFICANT.
TOTAL DEFECTS PER PATTERN.
PATT. NO. LEFT/EAR RIGHT/EAR TOTAL
1 8 7 15
2 11 8 19
3 16 10 26
4 14 17 31
SIGNIFICANT.

Fig. 8 — More detailed Multi-Vari Data Chart.

the dice after they are thrown, we can not be sure that all sides of both dice do not have just one dot each. On "legitimate" dice it is possible to do the same thing, but the odds are 1,300 to 1 against it. It is the objective of this program to make decisions where the odds of success are favorable.

Pilot runs are essentially production runs of multi-vari type which sometimes go all the way through the customer's machining and testing facilities. This helps determine the critical foundry controls necessary to assure final customer satisfaction. Such test runs are usually 50 pieces. There is no nondestructive testing technique in the world any better than this. Foundry control on subsequent production is thus mimimum in coverage, but specifically centered on those factors which make that casting right.

X-Plots

As processes are proved to be critical, they should be tied down and not removed later because of economic pressures. This is easier said than done. To withstand pressures, controls must be proved, and this requires forced experiments. If the defect can be turned off or on at will, it is sure to be controlled. The author's company uses the X-Plot which is merely a "cookbook" form for the analysis variance. An oversimplified definition of this statistical quality control tool is that it enables one to level out all of the natural variables of a process of job, and compare the results of one, two or three pairs of ideas mathematically. It then gives the mathematical odds of this relationship occurring by chance.

The experiment shown in Fig. 9 is balanced with six trials performed by each method. Each trial, or part of a test, is at least two pieces which can be either one or two molds. If there are more than two pieces per mold, then only one mold is required for each trial. Since there are four pieces in this parlicular mold, the example shows four castings per trial.

This particular X-Plot shown in Fig. 9 was run on a job which had no pattern of defect except a "within mold" difference. Rather than completely regating and rerigging the pattern, which is expensive, it was thought that a different sand might improve the overall quality to such an extent that regating would not be necessary.

Each of the pieces is rated by the rating scale shown at the bottom of the X-Plot (Fig. 10). Such a rating scale is not perfect, but quite acceptable where there are several castings per trial. Ranking from the best to the worst, one through 24, is more accurate as a general rule, and is usually done for that size experiment, but lots of 48 or more are seldom ranked because of the extra work involved.

The first trial was rated 0, 1, 3, and 3 for a total of seven points. Figure 10 is the last half of the X-Plot. All of the encircled figures for each idea are totaled and shown as 24 for the No. 3 facing and 41 for the No. 6 system. The new idea is lower, but this could still happen by chance. For instance, if a coin were flipped 65 times, the result might be 24 heads and 41 tails. Therefore, the statistical testing formula is followed, which will answer this question.

Naturally, the statistical calculation of this problem could be done by the usual analysis of variance format as shown in Table 2, but the principal idea of the X-Plot is to enable production line foremen to

TRIAL	METHOD TO BE USED	MOLD NOS.	REMARKS: (FOR EXAMPLE POUR TEMP, POUR TIME, MOLD HARD, TIME OF DAY)	MOLD CASTING NUMBER	DEFECT DESCRIPTION			MOLD CASTING NUMBER	DEFECT DESCRIPTION		
					TYPE	LOCATION	RATING		TYPE	LOCATION	RATING
1	# 6	1		1	SHRINK	NEXT TO	0				
	SYSTEM			2	"	EAR	1				
				3	"	OPPOSITE	3				
				4	"	GATE	3				
2	#3	2		1	"	"	0				
	FACING			2	"	"	1				
NEW IDEA				3	"	"	1				
				4	"	"	1				
3	#3	3		1	"	"	1				
	FACING			2	"	"	1				
NEW IDEA				3	"	"	1				
				4	"	"	3				
4	#6	4		1	"	"	1				
	SYSTEM			2	"	"	1				
				3	"	"	1				
				4	"	"	3				
5	#6	5		1	"	"	1				
	SYSTEM			2	"	"	1				
				3	"	"	1				
				4	"	"	3				
6	#3	6		1	"	"	0				
	FACING			2	"	"	1				
NEW IDEA				3	"	"	1				
				4	"	"	1				

Fig. 9 — X-Plot experimental layout first six trials.

set up and run an experiment, and then calculate the significance of the experiment themselves. This is virtually impossible if they must be taught the full analysis of variance principles and calculation. The answer to this problem has been the author's company's "X-Plot Analysis Form."

The "X-Plot Analysis Form" shown in Fig. 11 is filled out from the data shown on the X-plot experiment. The new idea total of 24 is written in and becomes (A) and is multiplied times letter (A) which is therefore 24 again, which equals 576. The present method total of 41 is written in and becomes letter (B) and is multiplied times (B) which equals 1681. The total of these two figures, 576 plus 1681, equals 2257 as letter (C). The grand total of 65 is handled similarly, and eventually equals 4225 as letter (E).

The individual trial totals are squared so that the seven becomes 49, the three becomes nine, etc., for a total of 395 as the total or letter (F).

Then the blocks are filled in on the right side of the "X-Plot Analysis Form" with the appropriate letter number. By following the divisions and subtractions indicated, a significance ratio is calculated. In this case the significance ratio was 12.8 which meant that no. 3 facing was proven superior to no. 6 system sand for this job. This distribution of scores could have happened by chance less than one time in 100 had there been no difference between the sands. Sometimes, however, such an experiment showing scores of 40 and 20 will not be significantly different due to the individual trial total variations. The X-Plot analysis form, by virtue of dealing in probability estimates, will clearly differentiate between the two cases described.

Thus, an overall improvement on this job was effected by the use of No. 3 facing, but the problem was not completely solved without changing the gate size and shape on certain patterns on this plate. This ultimately resulted in quality castings being produced consistently.

This technique gives the line foreman a bat and a chance to hit statistically. He is thus an active member of the quality improvement squad, not just a labor foreman. In fact, he is not allowed to make changes without using this technique and finds it necessary to use it almost daily.

Special statistically designed experiments* are utilized to solve specific problems when there are more variables or the operation is such that the X-Plot is not applicable.

*Dorian Shainin, "The Statistically Designed Experiment: A Tool for Process and Product Improvement," *Harvard Business Review*, July-August 1957.

TRIAL	METHOD TO BE USED	MOLD NOS.	REMARKS: (FOR EXAMPLE POUR TEMP, POUR TIME, MOLD HARD, TIME OF DAY)	MOLD CASTING NUMBER	DEFECT DESCRIPTION			MOLD CASTING NUMBER	DEFECT DESCRIPTION		
					TYPE	LOCATION	RATING		TYPE	LOCATION	RATING
7	#6	7		1	SHRINK	NEXT TO	0				
	SYSTEM			2	"	EAR	1				
				3	"	OPPOSITE	1				
				4	"	GATE	3				
8	#6	8		1	"	"	1				
	SYSTEM			2	"	"	1				
				3	"	"	3				
				4	"	"	3				
9	#3	9		1	"	"	0				
	FACING			2	"	"	1				
NEW IDEA				3	"	"	1				
				4	"	"	1				
10	#6	10		1	"	"	1				
	SYSTEM			2	"	"	2				
				3	"	"	3				
				4	"	"	3				
11	#3	11		1	"	"	0				
	FACING			2	"	"	1				
NEW IDEA				3	"	"	1				
				4	"	"	2				
12	#3	12		1	"	"	0				
	FACING			2	"	"	1				
NEW IDEA				3	"	"	1				
				4	"	"	3				

RATING SCALE
0-NO DEFECT
1-SMALL DEFECT - NOT SCRAP
2-MEDIUM DEFECT - SCRAP
3-HEAVY DEFECT - SCRAP

RANK TOTALS:
NEW IDEA 24 #3 FACING
PRESENT METHOD 41 #6 SYSTEM
GRAND TOTAL 65

Fig. 10 — X-Plot experimental layout last six trials.

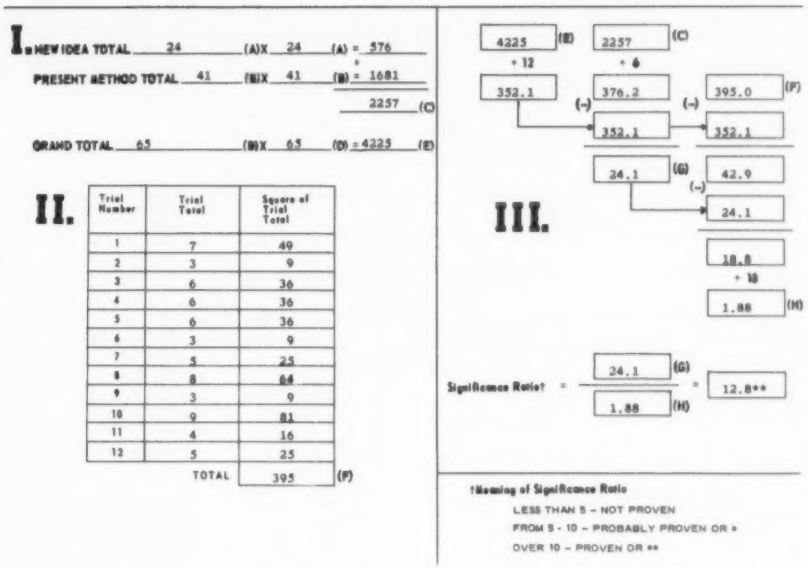

Fig. 11 — Author's company X-Plot Analysis Form for simplified testing of significance for methods tried in X-Plot.

CONCLUSIONS AND RECOMMENDATIONS

Results from this overall program have been extremely good. Figure 12 represents the history of the program showing that customer returns have been reduced substantially. This was not the main objective of the program but is certainly desirable. On the same chart is shown the history of the man-hours per ton expended in the quality control effort. Again a reduction in man-hours per ton was not the objective, but they are now less than ever before. This also includes clerical work on report systems and most of the experimental design and analysis for experiments. Only one salaried person was added into this entire program.

Figure 13 shows the total hard and soft iron scrap history. Results from this overall program have been beyond the most optimistic dreams, and it is not certain that the economic low per cent scrap has yet been achieved. The 12 months ending August 31, 1958, had a weighted average of 5.4 per cent. This is less than half the original 10.9 per cent average experienced prior to the inception of our quality improvement program.

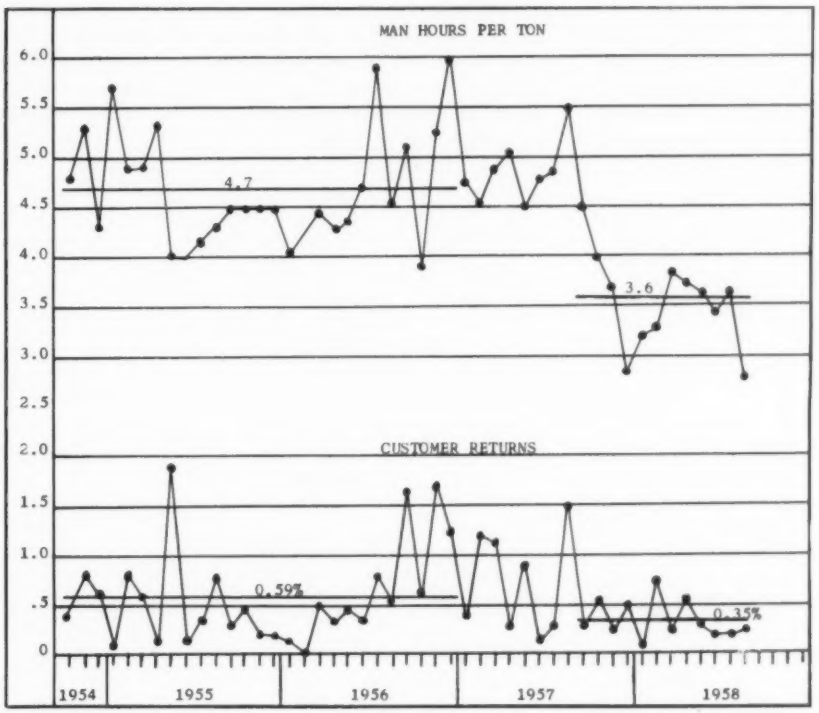

Fig. 12 — Quality control departmental man-hours per ton and customer returns as a percentage of shipments were both reduced during this program.

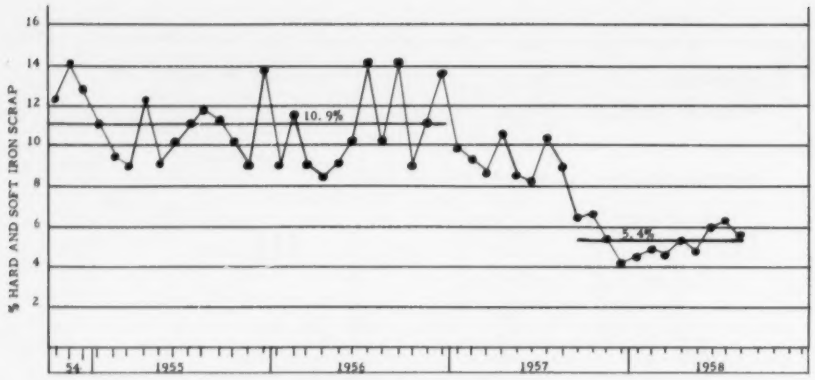

Fig. 13 — Total malleable division hard iron and soft iron scrap was reduced by 50 per cent during this program with further reductions still economically feasible.

TABLE 2 – NORMAL MATHEMATICAL CALCULATION OF ANALYSIS OF VARIANCE TO DETERMINE SIGNIFICANCE

	Mean (DF)	Main Effect (DF)	Residual (DF)
Total of squares	4,225	2,257	395
Number values per total	12	6	1
Uncorrected sum squares	352.1 (1)	376.2 (2)	395 (12)
Correction for the mean	352.1 (1)	352.1 (1)	352.1 (1)
Sum of squares corr. for mean	24.1 (1)	42.9 (11)	
Correction for main effect		24.1 (1)	
Sum of squares corr. for main effect		18.8 (10)	
Mean square, variance, or sigma squares	24.1	1.88	
Significance ratio	$\frac{24.1\ (1)}{1.88} = 12.8^{**}$		

$$F = \frac{1}{10} = \frac{4.96^{*}}{10.004^{**}}$$

*4.96 equals the 0.05 level which means that one time in 20 could a number as high as 4.96 occur by chance. This is rounded off to 5 on the X-Plot Analysis Form for sake of simplicity.

**10.04 equals the 0.01 level which means that one time in 100 could a number as high as 10.04 occur by chance. This is rounded off to 10 on the X-Plot Analysis Form for sake of simplicity.

The statistical aspects of the program herein are vitally important to the success of such a program, but must be combined with dynamic management of the efforts of quality control and production supervision to be most effective. The techniques of this program can be learned rapidly by qualified personnel of any organization.

Calculate the true costs for lack of quality. Determine if a few of the jobs, processes, defects, classes of castings, machines or other categories show that the Pareto concept is valid. Estimate the savings which might be made and the cost of such a program. If the savings are worth the expenditure of time and money, go after them because by so doing, greater customer satisfaction will be achieved with castings in contrast to fabrications, forgings, and the like. Foundries will be forced to produce better and more consistent castings if they are to be a progressive rather than a declining industry.

ACKNOWLEDGMENT

The author wishes to express his appreciation to the management of Texas Foundries, Inc., for its permission to carry out this program; to J. R. Speer, Jr., and F. W. Jacobs of Texas Foundries for their technical advice, and to the photographic department of this company for its assistance in preparing illustrations presented in this paper; and to all quality control department employees and foundry supervision at Texas Foundries for their wholehearted support of this program.

DIMENSIONING OF SAND CASTING RISERS

By Harish D. Merchant

ABSTRACT

A new approach for risering sand castings whereby a general equation for risers is obtained is developed. Using the equation, the size of riser or risers for a given casting can be easily found. The general equation is expressed in graphic form which is convenient to use, provided the values of the parameters of the equation are known. These are the solidification shrinkage at pouring temperature,* the ratio of height to diameter of riser and number of risers required.

INTRODUCTION

The dimensioning of sand casting risers has been more of an art than science in the foundry industry. The transition of risering from art to science was started in 1948 by Caine.[3] The approach to the dimensioning was empirical in character, and was applicable to a narrow set of conditions for certain specifications of steel. In actual working practice, such formulation for the dimensioning of risers quite frequently may fail to give satisfactory results. The reason is obvious. The working conditions of a foundry are extremely dynamic as compared to a laboratory. Thus, foundrymen prefer to use excessively large instead of analytically exact risers.

There are three problems involved in riser dimensioning: size, shape and position. Caine's[3] work throws light on size, while Bishop and others[4] in their work in 1955 tell in addition something about what should be the shape of the cylindrical riser. The later work also is partly empirical. The workers at Naval Research Laboratory have done some work on the position of risers on a casting. Again, it is an empirical type of study, and the authors suggest a set of rules, successful in the laboratory, for positioning a riser. Each of these problem areas is confined to nodular iron and steel for size and shape of the riser, and to steel only for positioning the riser.

This paper makes a different empirical approach to to dimensioning of risers as far as size and shape of the risers are concerned. The method is general in the sense that it can be applied to any type of metal or alloy. As in any scientific approach to a problem, a number of assumptions are made in the course of the paper as they tend to make the problem simpler. The risers considered are only top-insulated cylindrical risers, and data available in literature are used. A similar general approach can be used for the question of feeding distances of different risers, but no such attempt has been made here due to insufficient data.

CHVORINOV'S RULE

The risering requirements of a sand casting depend mainly upon two factors, viz., the thermal properties and the solidification characteristics of the metal. But the riser size would also be affected by the size and shape of casting and riser, type of sand used, the position of gate and riser and other infinite variety of situations under which the casting is made. In this study, in which cylindrical top-insulated risers are considered, the following variables are considered:

V_c – volume of casting.
S_c – surface of casting.
V_r – volume of riser.
S_r – surface of riser.
b – solidification shrinkage at pouring temperature.
c – contant for the metal dependent on solidification behavior.

According to Chvorinov,[1] the time a metal body remains molten is proportional to the square of the ratio, volume (V) to surface area (S) of the body. Thus, the time molten for casting is

$$T_c a \frac{V_c^2}{S_c^2}$$

and the time molten for riser is

$$T_r a \frac{V_r^2}{S_r^2}$$

Most frequently a top-insulated riser is used, as this type of riser is little affected by the position of gates,[2] and for a number of other obvious advantages. Now, taking into account the top-insulated riser,

$$T_r = K_r \frac{V_r^2}{S_r^2}$$

*The term "solidification shrinkage at pouring temperature" is used repeatedly. It does not mean solidification shrinkage that occurs at the pouring temperature, but implies that the solidification shrinkage may vary with varying pouring temperature, and this paper considers only that solidification shrinkage which occurs when the metal is poured at the pouring temperature in question.

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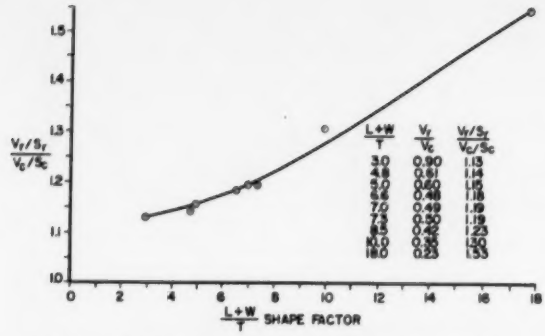

Fig. 1 — Relationship between shape factor and freezing ratio where L+W/T is plotted against the freezing ratio $\frac{V_r/S_r}{V_c/S_c}$. As the former increases, the latter also increases.

$$T_c = K_c \frac{V_c^2}{S_c^2}$$

$$\therefore \frac{T_r}{T_c} = \frac{K_r}{K_c} \quad \frac{V_r^2/S_r^2}{V_c^2/S_c^2} = K \frac{V_r^2/S_r^2}{V_c^2/S_c^2}$$

where, $K_r/K_c = K$

if $K_r = K_c$, $K = 1$

and $$\frac{T_r}{T_c} = \frac{V_r^2/S_r^2}{V_c^2/S_c^2}$$

Obviously, $K_r = K_c$ when at any moment the rate of heat dissipation of riser is same as that of casting, which in turn can happen only when the riser and the casting have the same shape, both are poured at the same temperature and are, in general, cooling under similar conditions. Sometimes, using the last equation, attempts have been made to dimension a riser for a given casting by an argument that the riser should remain molten 1½ times (or some such arbitrary number) the time the casting may remain molten. This is the same as selecting an arbitrary T_r/T_c and substituting in the equation

$$\frac{T_r}{T_c} = \frac{V_r^2/S_r^2}{V_c^2/S_c^2}$$

to find the riser dimension. This equation is only true when $K = 1$, which happens only under the restrictions explained. Hence the Chvorinov's rule[1] cannot be applied rigorously without knowing K or K_r and K_c.

$\frac{V_r/S_r}{V_c/S_c}$ or $\sqrt{\frac{1}{K} \cdot \frac{T_r}{T_c}}$ is known as a freezing ratio, which is low for chunky castings like cubes and spheres, and high for thin and long castings like plates and bars. For steel, this can be easily shown by combining the curves obtained by Caine[3] and Bishop and others.[4] The former has presented a curve of freezing ratio vs. V_r/V_c and the latter, a curve of $L+W/T$ vs. V_r/V_c

where: L = length of casting
W = width of casting
T = thickness of casting

Instead, here $L+W/T$ is plotted against freezing ratio $\frac{V_r/S_r}{V_c/S_c}$ (Fig. 1). It is obvious that, as $L+W/T$ increases, freezing ratio increases. The curve by Bishop and others[4] is only true when the ratio of height of the riser (H) to the diameter of the riser (D) is between 0.5 and 1. Hence, Fig. 1 is only true when H/D is between 0.5 to 1. Actually, a series of such curves may be obtained for different values of H/D, if exact data are available.

From the above discussion we can conclude that Chvorinov's rule[1] is a complex mathematical relation for a given set of casting conditions between the freezing ratio, shape of riser and shape of casting. Curves obtained by Caine[3] and Bishop and others[4] are thus a restatement of Chvorinov's rule; the only difference being that Chvorinov did not consider the shape variable, and considered freezing ratio constant for a metal body irrespective of its shape.

RISERING FOR STEEL

The results obtained for steel by Bishop and others[4] were thoroughly studied. From their data, riser volume (V_r), riser surface (S_r), casting volume (V_c) and casting surface (S_c) were calculated (Table 1). A graph of V_r/V_c and S_r/S_c was plotted (Fig. 2). A linear relation obtained is given by

$$\frac{S_r}{S_c} = m \frac{V_r}{V_c} - c' \qquad (1)$$

where m and c' are constants. For steel, $m = 0.81$, $c' = 0.041$; making the equation,

$$\frac{S_r}{S_c} = 0.81 \frac{V_r}{V_c} - 0.041 \qquad (2)$$

Substituting, $m = \frac{1}{c}$ and $\frac{c'}{m} = b$, $x = \frac{V_r S_c}{S_r V_c}$ and $y = \frac{V_r}{V_c}$ in equation (1) we get,

$$x = \frac{cy}{y - b} \qquad (3)$$

where b and c are constants. For steel,

$$x = \frac{1.265\ y}{y - 0.050} \quad \text{(Fig. 3)} \qquad (4)$$

Now, Caine[3] obtained the relation in the form of,

$$x = \frac{a}{y - b} + c$$

where a, b and c, are constants, or

$$x = \frac{0.12}{y - 0.05} + 1 \quad \text{(Fig. 4)} \qquad (5)$$

What he presumably did was to reason two points (∞, b) and (c, ∞), and then fit a curve on the scatter diagram obtained by the experiments. But, mathematically speaking, two points are not sufficient to define a curve. From the points (∞, b) and (c, ∞) a number of curves can be obtained such as,

TABLE I – RISER DATA, STEEL

No.	Size	V_c	S_c	Min. Riser D	Min. Riser H	V_r	S_r	$\frac{V_c}{S_c}$	$\frac{V_r}{S_r}$	$\frac{V_r}{V_c}$	$\frac{S_r}{S_c}$	$X = \frac{V_r S_c}{S_r V_c}$
1	2x4x8	64	112	3½	4	38.4	49.6	0.57	0.72	0.60	0.48	1.40
2	2x8x8	128	192	5	2½	49	58.9	0.67	0.83	0.38	0.31	1.24
3	2x4x12	96	160	4½	4	63.6	72.4	0.6	0.88	0.66	0.45	1.47
4	2x12x12	288	384	6	3½	99	94.1	0.75	[illegible]	0.34	0.25	1.40
5	2x24x24	1152	1344	6	8	230	179	0.86	1.28	0.20	0.13	1.46
6	2x25x25	1250	1450	7	4¼	175	131.9	0.86	1.33	0.14	0.091	1.54
7	2x25x25	1250	1450	8	3	150	125.7	0.86	1.19	0.12	0.087	1.38
8	2x36x36	2590	2880	8	6½	330	213.6	0.90	1.54	0.12	0.74	1.71
9	2x36x36	2590	2880	12	4½	510	282.7	0.90	1.80	0.20	0.098	2.00
10	3x3x9	81	126	4½	3½	56	65.4	0.64	0.86	0.69	0.52	1.34
11	3x9x9	245	270	5½	6	143	127.4	0.91	1.12	0.59	0.59	1.23
12	3x6x12	216	252	7	2	79	82.5	0.86	0.96	0.36	0.36	1.12
13	3x9x12	325	342	6	4½	127	113.1	0.95	1.11	0.39	0.33	1.16
14	3x12x12	435	432	6	5½	156	131.9	1.00	1.18	0.37	0.30	1.8
15	3x12x12	432	432	8	3	151	125.6	1.00	1.20	0.35	0.29	1.15
16	3x28x28	2350	1904	9	10	635	346.2	1.23	1.83	0.27	0.18	1.49
17	3x28x28	2350	1904	12	6	680	339.2	1.23	2.00	0.29	0.18	1.63
18	4x4x4	64	96	5	3	58	66.8	0.67	0.88	0.92	0.69	1.31
19	4x4x4	64	96	6	1½	42.5	56.6	0.67	0.75	0.66	0.59	1.12
20	4x4x8	128	160	6	3½	99	94.3	0.80	1.05	0.77	0.98	0.789
21	4x4x12	192	224	6	5	141	122.5	0.86	1.15	0.72	0.55	1.33
22	4x4x18	288	320	6	4	113	103.7	0.90	1.09	0.40	0.32	1.21
23	4x4x20	320	352	7	4	155	126.1	0.91	1.23	0.48	0.36	1.35
24	4x4x28	448	480	11	1½	143	146.8	0.93	0.97	0.32	0.37	1.04
25	4x4x31	495	528	7	5	193	148.4	0.94	1.30	0.38	0.28	1.38
26	4x20x20	1600	1120	10	11	863	423.9	1.43	2.04	0.54	0.38	1.43
27	4x20x20	1600	1120	13	5½	735	357.2	1.43	2.09	0.46	0.32	1.46
28	4x25x25	2400	1650	10	13	1020	486.7	1.45	2.17	0.42	0.29	1.50
29	7x7x7	342	294	9	5	320	204.9	1.16	1.56	0.92	0.70	1.34
30	4x4x12	192	224	6	5	141	122.5	0.86	1.15	0.73	0.55	1.33
31	4x4x28	448	480	7	6	232	170.4	0.93	1.36	0.53	0.35	1.46

$$x = \frac{a}{y-b} + c \qquad A$$

$$x = \frac{a}{(y-b)^2} + c \qquad B$$

$$x = \frac{a}{(y-b)^3} + c \qquad C$$

$$x = \frac{y-b+c}{y-b} \qquad D$$

$$x = \frac{cy}{y-b} \qquad E, etc.$$

None of these curves can be expressed in the form of equation (1), $\frac{S_r}{S_c} = m\frac{V_r}{V_c} - c'$, except for equation (E).

A comparison between equation (4) and (5) is given in Fig. 5a. The differences in two curves obtained probably may be due to one or more of the following reasons:

1) Bishop[4] judged defective castings by radiographs, Caine[3] used no radiographs.
2) In calculating the surface areas of riser and casting, the area of the plane of intersection of riser and casting was excluded from riser surface but included in casting surface. In doing so, a better fit on the scatter diagram was obtained. Caine[3] may or may not have included this area into riser and casting surface areas.
3) Bishop and others[4] made an assumption from their laboratory experience "that the minimum riser required for a given shape which had been fed with a slightly oversize riser could be established with reasonable accuracy by subtracting from the riser height the distance by which the tip of the riser shrinkage missed the contact line."[5] It is not known how Caine[3] obtained the minimum risers.
4) The equations (2) and (4) are obtained by the least square method so as to get the best fit on the scatter diagram. It is not known how Caine

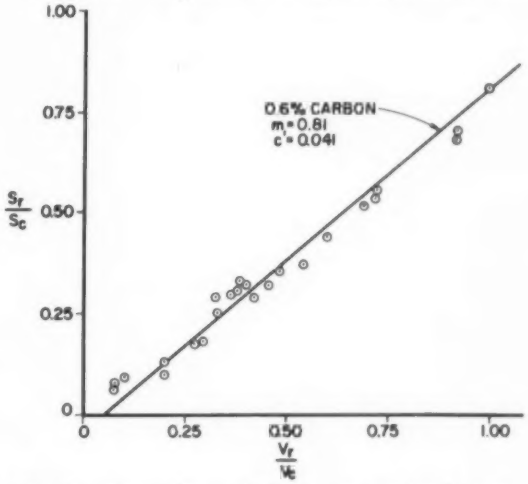

Fig. 2 — From data of Bishop and others,[4] riser volume (V_r), riser surface (S_r), casting volume (V_c) and casting surface (S_c) were calculated, and the scatter graph of steel data ($S_r/S_c \rightarrow V_r/V_c$) was plotted.

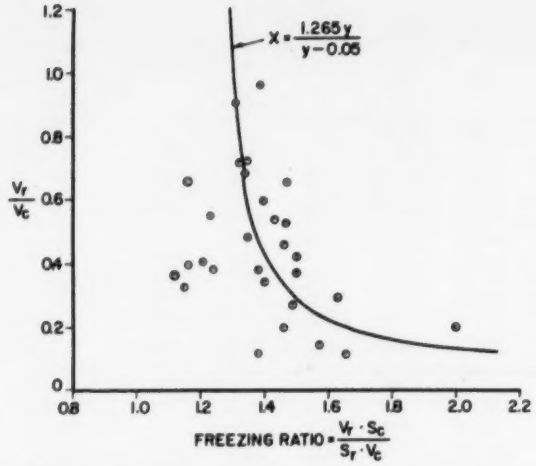

Fig. 3 — The scatter graph of steel data plotted with freezing ratio (F.R.) — F.R. $= V_r/V_c$.

obtained the experimental curve in Fig. 4. By the method of least squares, equation (5) is almost unobtainable unless one of the constants *a*, *b*, or *c*, is known. If the dotted experimental curve is roughly drawn on a scatter diagram, and a theoretical curve is made to fit on it, this can be misleading. It would also be incorrect to assume that any point falling on right of the curve would be invariably sound, and on left, invariably defective. Within certain limits,[4] all the "just sound" and "just defective" points will fall on both sides of the curve between a narrow strip. The limits, however, are difficult to define as the casting conditions change from foundry to foundry. It would be safe to utilize this average curve, unless a casting absolutely free from microshrinkage is to be obtained.

5) Bishop[4] varied the ratio of height to diameter of the riser (H/D). As explained later (Fig. 6), the ratio H/D changes riser requirements considerably, particularly in chunky castings. H/D ratios used by Bishop[4] are mostly less than one.

TABLE 2 – (OPEN INSULATED) RISER DIAMETER FOR STEEL WHEN D = H

Casting	Caine's Equations[3] (Equ. 5)	Bishop and others[4] (Ave. Curve)	New Riser Equation (Equ. 4)
4x4x4	4.50	4.70	4.3
2x4x8	4.05	3.50	3.75
1x8x8	3.30	2.75	3.00

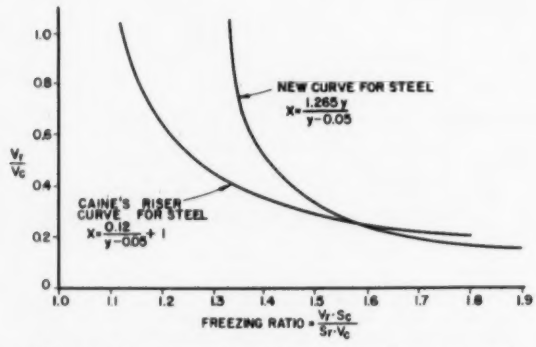

Fig. 5a — A comparison between equation (4) and (5) showing Caine's[3] curve and the new curve for steel.

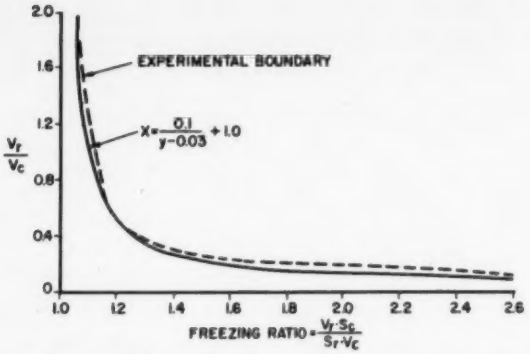

Fig. 4 — Graphs from Caine[3] where a, b and c are constants, or $x = \dfrac{0.12}{y - 0.05} + 1$.

Riser dimensions for steel were calculated by using equations (4) and (5). In equation (4), the area of plane of intersection is excluded from riser surface area but is included in casting surface area. In equation (5), the area of plane of intersection is included in both riser and casting surfaces. The riser dimensions for the same castings are also calculated from the average graph given by Bishop and others.[4] The results obtained by the three methods are presented in Table 2.

With the practical point of view, the results are not quite identical. Mathematically, equations (4) and (5) are identical when a = bc. When the area of the plane of intersection of riser and casting is included in both riser and casting surface areas, c = 1, b = 0.05 for both equations; and when the same area is included in casting surface only, c = 1.25, b = 0.05 for both equations (4) and (5) (Fig. 5b). According to equation (4), in the first case a = bc = 0.05 and in the second case a = bc = 0.0625. According to equation (5), a = 0.12.

This means that the only difference between Caine's curve (equ. 4) and new riser curve (equ. 5) is that the value of *a* is less in latter, so that the

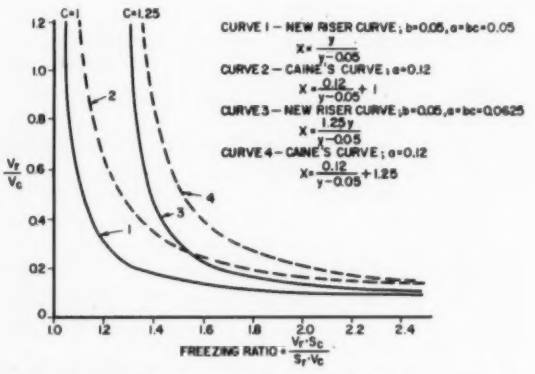
C=1
C=1.25
CURVE 1 – NEW RISER CURVE; b=0.05, a=bc=0.05
X = y / y−0.05
CURVE 2 – CAINE'S CURVE; a=0.12
X = 0.12 / y−0.05 + 1
CURVE 3 – NEW RISER CURVE; b=0.05, a=bc=0.0625
X = 1.25y / y−0.05
CURVE 4 – CAINE'S CURVE; a=0.12
X = 0.12 / y−0.05 + 1.25
Vr / Vc
FREEZING RATIO = Vr·Sc / Sr·Vc

Fig. 5b — New curve for steel, and Caine's[3] curve, for C = 1 and C = 1.25.

knee of the Caine's curve is shifted a little toward X and Y axes to give the new riser curve (Fig. 5a). As actual difference in the dimenstions of risers obtained by using equations (4) and (5) is not great, it would not make much difference using any of them (irrespective of which one gives "just sound" castings), if castings completely free from micro-shrinkage are not to be obtained. The area of the plane of intersection of riser and casting must not be included in riser surface, because often the riser is necked down, and the value of c obtained without the inclusion of this common area further helps in understanding the physical meaning of b and c (this will be explained later Fig. 12a).

For different values of $\frac{L+W}{T}$, $\frac{V_r}{V_c}$ was plotted against H/D. The data were obtained from the work of Bishop and others[4] (Fig. 6). $\frac{L+W}{T} = 2-4$ is for cubes or short bars, $\frac{L+W}{T} = 6-8$ is for long bars or short plates and $\frac{L+W}{T} = 10-12$ is for plates. It is apparent that we can use a lower riser volume, and hence obtain higher yield if low H/D ratio is used. This is particularly true, and perhaps is it necessary, for chunkier castings where $\frac{L+W}{T}$ is lower and savings in volume of riser by reducing H/D ratio are higher (Table 3).

Although all three lines (Fig. 6) are obtained by the least square method, the results, are not quantitatively exact due to insufficiency of data. However, the emphasis is clear that the risers with height smaller than diameter should be used for chunkier castings to obtain greater yield. In practice, the ratio H/D less than 0.5 becomes impracticable, due to difficulties of removing riser from the casting, and to the formation of a hot spot at the junction of riser and casting. Even necking down of the top riser does not help when the riser diameter is too large as compared to the height. Thus, it may be suggested that H/D between 0.5 and one should be used as it may be practicable.

TABLE 3 – EFFECT ON V_r/V_c OF USING DIFFERENT RISER HEIGHTS

$\frac{L+W}{T}$	H/D=1	H/D=0.5	(H/D = –1) – (H/D = ½)
2-4	1.6	0.78	0.82
6-8	0.58	0.34	0.24
10-12	0.40	0.28	0.12

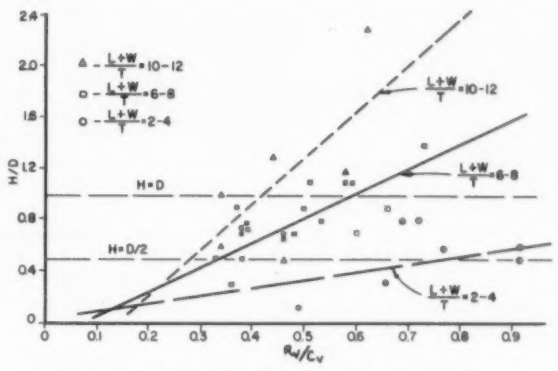

Fig. 6—Graph showing effect of H/D on riser volume.

RISERING FOR NODULAR IRON

Similar treatment, as for steel, was given to the results obtained by Bishop and Ackerlind[5] for nodular irons of different carbon equivalent. The data are given in Tables 4a, 4b and 4c. The graphs are again obtained by the least square method, and plotted in Figs. 7a and 7b. The values of m, c', b and c in equations (2) and (3), for nodular iron as well as steel, are summarized in Table 5.

It is easy to conclude that: (a) the values of b for nodular irons with different carbon equivalents conform fairly well with those obtained by the method proposed by Reynolds and others[6] (see Appendix A); (b) the riser requirements of nodular iron change drastically with change in carbon equivalent.

TABLE 4A – LOW-CARBON NODULAR IRON DATA (C.E. = 3.54-3.82)

No.	Size	V_c	S_c	Min. Riser D	Min. Riser H	V_r	S_r	$\frac{V_c}{S_c}$	$\frac{V_r}{S_r}$	$\frac{V_r}{V_c}$	$\frac{S_r}{S_c}$	$X = \frac{V_r S_c}{S_r V_c}$	C.E.
1	4x4x4	64	96	6	3¾	106	98.8	0.67	1.07	1.67	1.03	1.60	3.73
2	3x6x6	108	144	7	4½	173	137.4	0.75	1.26	1.60	0.95	1.68	3.66
3	3x6x6	108	144	7	4½	173	137.4	0.75	1.26	1.61	0.96	1.68	3.66
4	3x6x6	108	144	7	4½	173	137.4	0.75	1.26	1.61	0.96	1.68	3.66
5	3x3x15	135	198	7	3½	135	115.4	0.68	1.17	1.00	0.58	1.72	3.66
6	3x3x15	135	198	7	3⅞	150	123.6	0.68	1.21	1.11	0.62	1.77	3.66
7	3x3x15	135	198	6	4½	127	113	0.68	1.12	0.94	0.57	1.65	3.66
8	2x8x8	128	192	7	3	116	105.5	0.67	1.10	0.90	0.55	1.64	3.66
9	2x8x8	128	192	7	3½	135	115.4	0.67	1.17	1.06	0.60	1.75	3.66
10	2x8x8	128	192	6	4¼	120	108.3	0.67	1.11	0.94	0.56	1.66	3.66
11	4x4x4	64	96	6	3½	99	94.1	0.67	1.05	1.54	0.98	1.57	3.73
12	2x14x14	392	504	7	4¼	279	197.4	0.78	1.44	0.71	0.39	1.85	3.67
13	1x8x8	64	160	3½	3	29	37.4	0.4	0.775	0.45	0.23	1.94	L3.54
14	1x12x12	144	336	5	3¼	64	70.7	0.43	0.905	0.44	0.21	2.11	L3.54
15	1x14x14	196	448	5	3	59	66.8	0.44	0.883	0.30	0.30	2.02	3.77
16	1x14x14	196	448	5	3¼	64	70.7	0.44	0.905	0.33	0.14	2.07	H3.82
17	1x14x14	196	448	5	3¼	64	70.7	0.44	0.905	0.33	0.14	2.07	H3.82

TABLE 4B – MEDIUM-CARBON NODULAR IRON DATA (C.E. = 3.88-4.32)

No.	Size	V_c	S_c	Min. Riser D	Min. Riser H	V_r	S_r	$\frac{V_c}{S_c}$	$\frac{V_r}{S_r}$	$\frac{V_r}{V_c}$	$\frac{S_r}{S_c}$	$X = \frac{V_r S_c}{S_r V_c}$	C.E.
1	6x6x6	216	216	6	5	140	122.5	1	1.15	0.65	0.57	1.15	L3.88
2	6x6x6	216	216	8	4½	226	164	1	1.38	1.05	0.76	1.38	L3.88
3	3x6x6	108	144	5	3¼	64	70.7	0.75	0.905	0.60	0.49	1.21	H4.09
4	4x4x20	320	352	8	5	235	176	0.91	1.34	0.80	0.5	1.46	L3.88
5	4x4x20	320	352	6	4¼	128	113	0.91	1.13	0.40	0.32	1.45	Hy4.32
6	2x8x8	128	192	5	3¼	64	70.7	0.67	0.91	0.50	0.37	1.36	H4.09
7	2x10x10	200	280	6	4½	128	113	0.71	1.13	0.64	0.40	1.59	L3.88
8	2x10x10	200	280	6	4½	128	113	0.71	1.13	0.64	0.40	1.59	L3.88
9	2x6x18	216	308	6	3	85	84.8	0.70	1.00	0.39	0.28	1.43	H4.09
10	2x14x14	392	504	8	5	235	176	0.78	1.34	0.64	0.35	1.72	L3.88
11	1x14x14	196	448	5	3½	69	64.7	0.44	1.01	0.35	0.15	2.30	L3.88
12	1x12x12	144	336	5	3½	44	57	0.43	0.77	0.30	0.17	1.80	H4.09

General Equation for Risers

Studying Table 5, one can easily notice that c' is constant for nodular iron as well as steel. c was plotted against b. A linear relation was obtained which has the equation (Fig. 8),

$$c = 25b \qquad (6)$$

Now, the new riser equation is given by,

$$\frac{S_r}{S_c} = m\frac{V_r}{V_c} - c' \qquad (1)$$

Substituting,

$$S_r = \pi/4\ D^2 + \pi DH$$
$$V_r = \pi/4\ D^2 H$$
$$H/D = p$$

equation (1) can be expressed in the form,

$$\frac{(4p+1)}{S_c} = \frac{p\,m\,D}{V_c} - \frac{1.275c'}{D^2} \qquad (7)$$

Substituting, $m = \frac{1}{c}$ and $c' = \frac{b}{c}$, equation (7) can be expressed in the form of,

$$\frac{(4p+1)c}{S_c} = \frac{p\,D}{V_c} - \frac{1.275b}{D^2} \qquad (8)$$

Substituting, equation (6) (c = 25b) in equation (8),

$$\frac{25(4p+1)}{S_c} = \frac{p\,D}{b\,V_c} - \frac{1.275}{D^2} \qquad (9)$$

This is the general equation of the riser. The results obtained by using it are almost identical to those of Caine[3], or Bishop and others.[4,5]

If the casting is big, one riser, however big, is not capable of supplying metal to all parts of the casting. In such cases, more than one riser is needed. If n = the number of risers needed, equation (9) can be expressed as,

$$\frac{25(4p+1)}{S_c} = \frac{p\,D}{b\,V_c} - \frac{1.275}{n\,D^2} \qquad (10)$$

In other words, 1/nth part of casting be treated as a single riser system by dividing S_c and V_c each by n.

Equations (9) and (10) cannot be expressed graphically as there are five variables p, b, D, S_c, V_c. If p, b are known, a graphical relation between D, V_c and S_c can be established (Figs. 9, 10, 11 and 11a).

Equation (9) was used by the author* for risering gray iron of carbon equivalents 3.5, 3.75 and 4 (silicon

*This experimental work was done by the author at Larson Foundry, Grafton, Ohio.

TABLE 4C – HIGH-CARBON NODULAR IRON DATA (C.E. = 4.63-4.81)

No.	Size	V_c	S_c	Min. Riser D	Min. Riser H	V_r	S_r	$\frac{V_c}{S_c}$	$\frac{V_r}{S_r}$	$\frac{V_r}{V_c}$	$\frac{S_r}{S_c}$	$X = \frac{V_r S_c}{S_r V_c}$	C.E.
1	4x4x4	64	96	3	1	20	35.4	0.67	0.57	0.31	0.37	0.85	H4.81
2	4x4x4	64	96	4¼	1¼	20	33.4	0.67	0.60	0.31	0.35	0.90	H4.81
3	4x4x13½	216	248	3½	6	58	75.4	0.87	0.77	0.27	0.30	0.90	4.63
4	4x4x13½	216	248	4	4	50	63.2	0.87	0.79	0.23	0.26	0.91	4.63
5	4x4x13½	216	248	4½	3¼	52	61.9	0.87	0.84	0.24	0.25	0.96	4.63
6	3x3x15	135	198	5	1¾	34	47.2	0.68	0.72	0.25	0.24	1.06	H4.81
7	3x3x15	135	198	5	1¾	34	47.2	0.68	0.70	0.25	0.24	1.06	H4.81
8	2x8x18	128	192	3½	2¾	26	39.8	0.67	0.65	0.20	0.21	0.97	4.62
9	2x10x10	200	280	5	1¾	34	47.2	0.71	0.72	0.17	0.17	1.01	4.62
10	2x10x10	200	280	4	2¼	28	41.3	0.71	0.68	0.14	0.15	0.95	4.62
11	2x6x18	216	308	6	2	56	65.9	0.70	0.85	0.26	0.32	1.21	L4.41
12	1x8x8	64	160	3	2¼	16	28.2	0.40	0.57	0.25	0.18	1.42	H4.81
13	1x8x8	64	160	3	2	14	25.9	0.40	0.54	0.22	0.16	1.35	H4.81
14	1x8x8	64	160	3	1½	11	21.2	0.40	0.52	0.17	0.13	1.29	H4.81
15	1x12x12	144	336	4	2½	31	44.4	0.43	0.70	0.22	0.13	1.63	4.49
16	1x12x12	144	336	3½	3¼	31	45.5	0.44	0.68	0.22	0.13	1.57	4.49
17	1x14x14	196	448	4	3	38	50.7	0.44	0.75	0.19	0.11	1.71	H4.81
18	6x6x6	216	216	4	4½	57	69.5	1	0.82	0.28	0.32	0.82	4.3
19	6x6x6	216	216	6	2	57	66	1	0.87	0.28	0.31	0.87	4.3

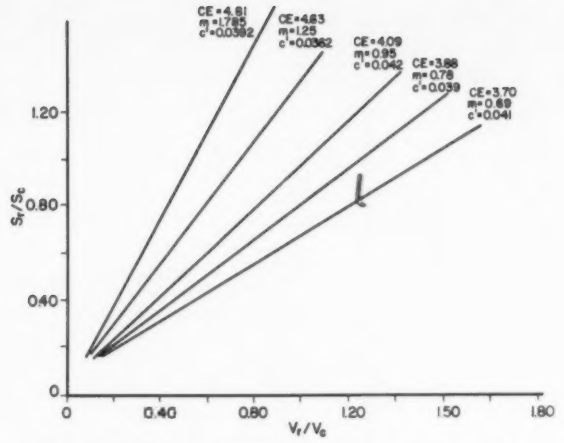

Fig. 7a — Scatter graph for nodular iron data (S_r/S_c ➙ V_r/V_c).

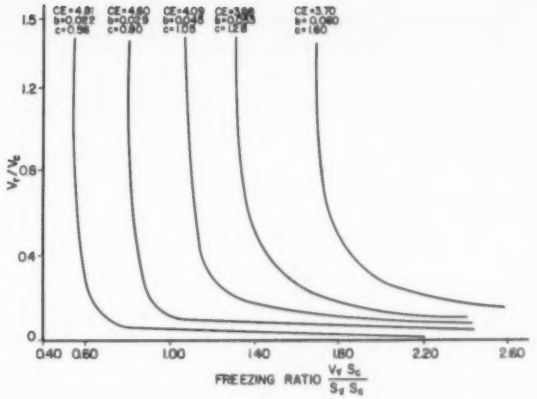

Fig. 7b — Scatter graph for nodular iron data (as Fig. 7a). The graphs were obtained by the least square method.

= 1.5 per cent). The results were quite satisfactory. The graphs obtained from equation (9), when D = H, for these grades of gray iron are plotted in Figs. 9, 10, 11 and 11a.

The Constants b and c

It is suggested that equation (9) may be used for any metal or alloy if its solidification shrinkage for pouring temperature, i.e., *b* is known. The solidification shrinkage for different metals can be found in the literature, or can be calculated by a number of formulas available. It is supposed that the liquid shrinkage does not play an important role in riser size for these reasons:

(1) Considerable amount of metal to compensate for the liquid shrinkage is supplied through the ingates before they freeze.

(2) The metal, when it reaches the riser, after passing through the gating system and the casting, is considerably colder than pouring temperature and much nearer to the liquidus temperature. The riser remains molten for more time just due to its shape, and not because it has a far higher temperature than the ingate before the liquidus temperature is reached.

(3) The solidification shrinkage increases with the superheat in some metals. This is particularly true when the superheat is excessive.[10,11] There is a high degree of variation in shrink depth in a riser due to superheat particularly when riser is insulated and risering is marginal.[11]

Actually, what we are interested in is that all the shrinkage, gross or microshrinkage, should be confined to the riser. Just adequate risers can only be obtained by a close control of the pouring temperature. It should not be below a certain minimum, nor should it be above a certain maximum.[11] In other words, a certain range of superheat is preferable for sound castings. The gross shrinkage often closely follows the superheat, but microshrinkage does not necessarily do so. The relation between superheat and shrinkage becomes quite confusing, particularly when a casting free from microshrinkage is required.[11] However, high-temperature gradients can reduce microshrinkage to a certain extent, while low-temperature gradients may transform gross shrinkage into microshrinkage. The methods, for finding solidification shrinkage of different grades of gray iron poured at 2500 F, and different grades of nodular iron poured at 2550 F, are described in the Appendix A.

TABLE 5—VALUES OF GENERAL EQUATION CONSTANTS

Metal	C.E.	m	c'	$b=\frac{c'}{m}$	$c=\frac{1}{m}$	$\frac{c}{b}=\frac{1}{c'}$	Comparative area of dend. mushy zone Ref. 7,8,9*
Nodular	3.7	0.69	0.041	0.060	1.44	24.0	9
Nodular	3.88	0.78	0.039	0.053	1.28	26.4	6
Nodular	4.09	0.95	0.042	0.045	1.05	24.3	—
Nodular	4.30	—	—	0.042	—	—	0
Nodular	4.63	1.43	0.041	0.029	0.70	24.7	—
Nodular	4.81	2.00	0.040	0.020	0.50	24.7	—
Steel	—	0.81	0.041	0.050	1.24	24.8	5.5
Gray Iron	3.5	—	—	0.033	—	—	9.75
Gray Iron	3.86	—	—	0.024	—	—	8.75
Gray Iron	4.13	—	—	0.015	—	—	4

*This is the comparative area of dendritic mushy zone between 2 and 3 in. from the interface.

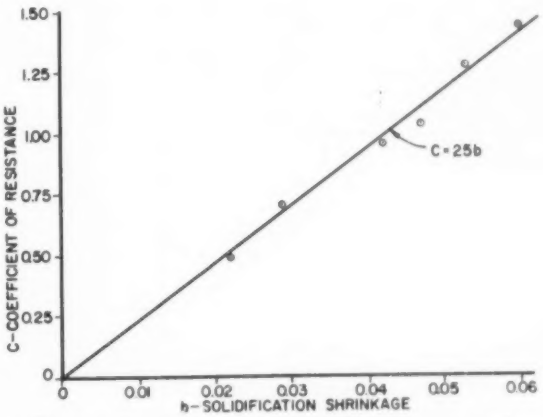

Fig. 8 — Graph showing relationship between coefficient of resistance against solidification shrinkage.

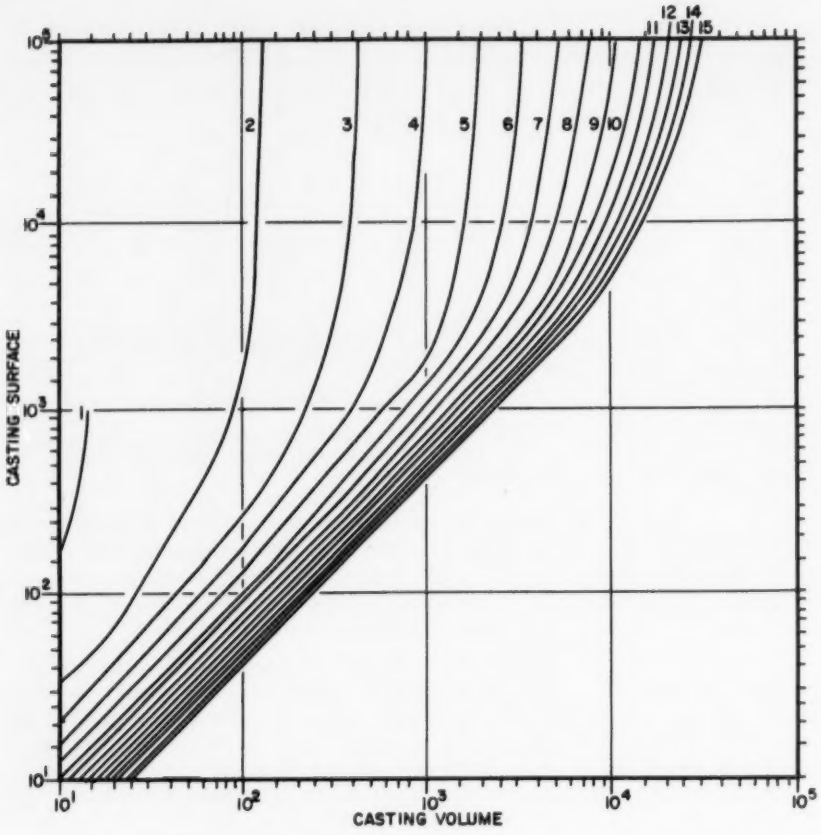

Fig. 9 — Graph for riser diameter, b = 0.05.
Steel: 0.6% C, 0.51% Mn, 0.3% Si. P.T. — 2800 F.
Nodular Iron: 3.17% C, 2.5% Si. C.E. — 4. P.T. — 2550 F.
Malleable Iron: 2.5% C, 1.0% Si. C.E. — 2.83. P.T. — 2550 F.
NOTE: Gray or malleable iron, if poured at temperatures higher than 2500 F, an increase of 0.25 per cent shrinkage must be made for 200 F excess over 2500 F.

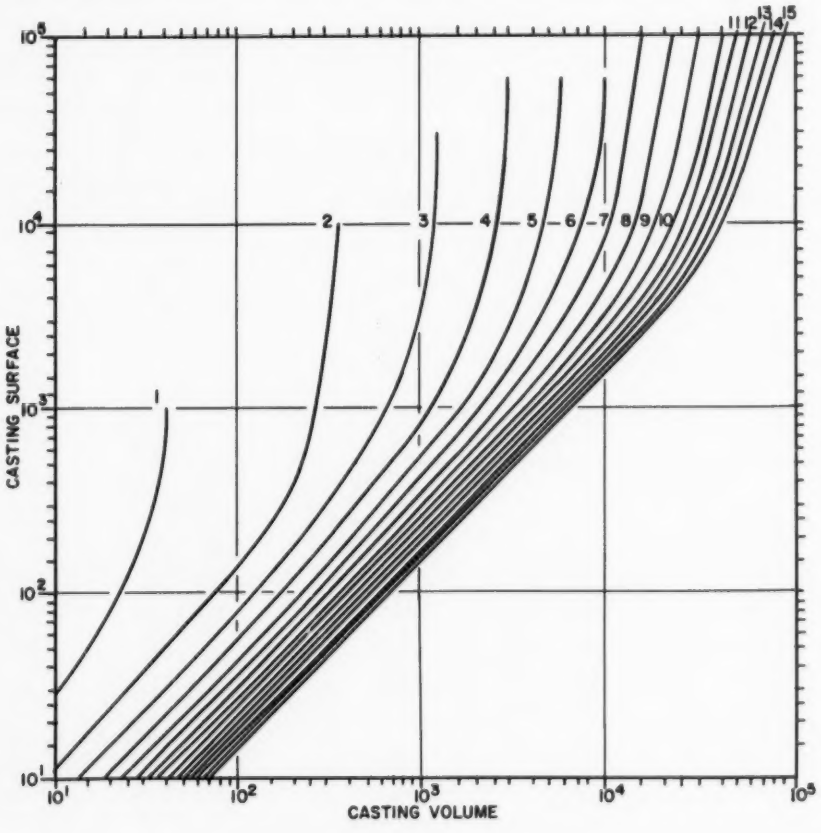

Fig. 10 — Graph for riser diameter, b = 0.0175, when D = H.
Gray Iron: 3.5% C, 1.5% Si. C.E. — 4. P.T. — 2500 F.
Nodular Iron: 4.09% C, 2.5% Si. C.E. — 4.92. P.T. — 2550 F.
NOTE: Gray or malleable iron, if poured at temperatures higher than 2500 F, an increase of 0.25 per cent shrinkage must be made for 200 F excess over 2550 F.

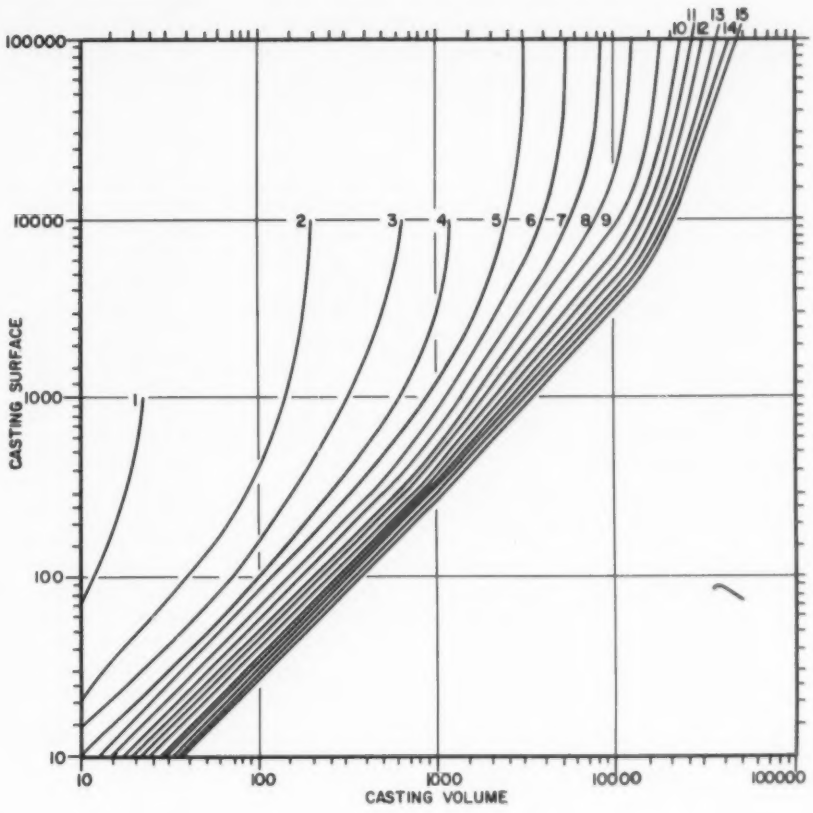

Fig. 11 — Graph for riser diameter, b = 0.033, when D = H.
Gray Iron: 3.0% C, 1.5% Si.
C.E. — 3.5. P.T. — 2500 F.
Nodular Iron: 3.7% C, 2.5% Si.
C.E. — 4.53. P.T. — 2550 F.
NOTE: Gray or malleable iron, if poured at temperatures higher than 2500 F, an increase of 0.25 per cent shrinkage must be made for 200 F excess over 2500 F.

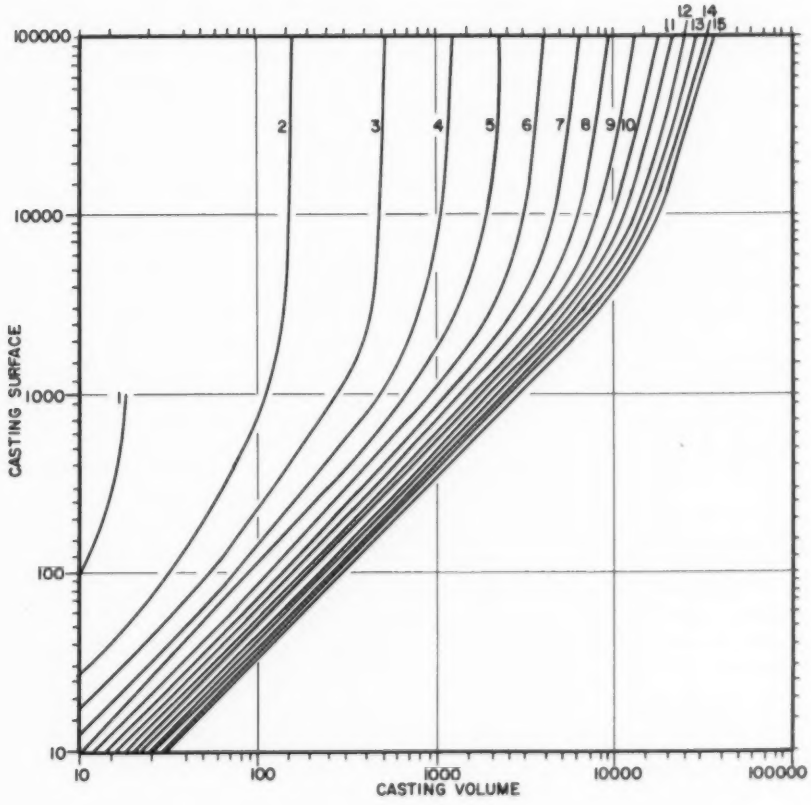

Fig. 11a — Graph for riser diameter b = 0.04, when D = H.
Nodular Iron: 3.37% C, 2.5% Si.
C.E. 4.2. P.T. — 2550 F.
Pure copper, (if b=0.04).
Gray Iron: 2.75% C, 1.5% Si.
C.E. — 3.25, P.T. — 2500 F.
NOTE: Gray or malleable iron, if poured at temperatures higher than 2500 F, an increase of 0.25 per cent shrinkage must be made for 200 F excess over 2500 F.

The function of a riser is to supply metal to the casting. There can be resistance to this supply if dendrites or eutectic are formed. If we say that coefficient of resistance for any such metal is one, it means the metal has no resistance to the flow of metal from the riser to the casting. Most metals form dendrites or eutectic when they solidify. Thus, for most metals c, i.e., coefficient of resistance, must be greater than one, except some kind of "self-feeding" tends to reduce the value of c, as in gray iron and nodular iron, due to precipitation of graphite, which is far lighter than the rest of the metal.

In gray iron, there can be three things happening during the passage of metal from riser to the casting:

1) Resistance due to dendrites.
2) Resistance due to eutectic cells.
3) Self-feeding due to localized volumetric expansion.

Dendrite Resistance

The resistance due to dendrites is zero at liquidus temperature, and maximum at the beginning of eutectic formation. The eutectic resistance is zero at the beginning of eutectic formation, and maximum at the end of eutectic formation. During the formation of eutectic, the dendritic resistance remains constant. Of course, the dendritic and eutectic resistances depend upon the way in which each is formed. The total resistance would be zero at liquidus, and maximum at the end of eutectic formation.

In gray iron, ordinarily graphite arises from a eutectic transformation of liquid to austenite and graphite. In mottled iron some of the graphite is formed indirectly by the decomposition of a carbide after solidification. Type[9] D undercooled graphite may be formed by one of these two possible ways.[12] The growth and three-dimensional shape of normal and undercooled graphite is fundamentally the same, i.e., "from the common center by branched crystallization interconnected";[12] while the growth of graphite obtained by the decomposition of cementite is by the diffusion of graphite through the layer of austenite, and graphite and the flakes are supposedly separated from one another.

In nodular iron, the carbon precipitates from the unstable undercooled liquid as a cloud of minute platelets which, after being transformed through a phase of liquid crystal, agglomerate in the form of nodules due to high surface energy between the liquid crystal of graphite and the remaining liquid.[13] This is called the primary graphite, and is formed out of liquid. The secondary graphite occurs as a result of decomposition of cementite in the solid state.[13] Thus, in gray iron, the passage of metal from riser to metal during eutectic formation is by liquid flow, while in nodular iron it is presumably by plastic flow. Hence, the eutectic resistance is more in nodular iron than in gray iron. Also, in nodular iron, under the conditions of rapid cooling, the interdendritic feed channels may become blocked by carbide, increasing the eutectic resistance.[14,15]

In gray iron most of the graphite is formed out of liquid and interconnected, while the rest of it is formed in solid form and separated so that less self-feeding is possible. It must be noted that self-feeding does not actually reduce the resistance to metal passage, but reduces the quantity of metal required by the casting, and thus superficially reduces the value of coefficient of resistance (c), sometimes even less than unit. Sometimes, heavy dendrites altogether prevent the passage of metal to or from the casting. In such cases, inadequate or no self-feeding results in unavoidable interdendritic shrinkage, and over-adequate self-feeding results in swells.[16] Such swells may be found in gray or nodular iron, though more frequent in nodular iron, as it is unable to relieve the self-feeding by liquid flow as does gray iron.

The constant c in equation (3) is the coefficient of resistance discussed above, and constant b is the solidification shrinkage of the metal at the pouring temperature. Caine[3] determines the constants b and c in equation (5) thus: "If the riser freezes infinitely slowly in relation to the casting, the riser volume required is equal to the volume of contraction on solidification. If the riser freezes at the same rate as the casting, the riser volume required is infinity." Then, citing the Chvorinov's[1] rule, he deduces that relative freezing time to complete solidification is unity when the riser freezes at the same rate as the casting. This may not always happen, because the relative freezing time to complete solidification also depends upon the resistance offered by the dendrites and eutectic cells formed during solidification.

Shape and Resistance Factors

Considering the shape factor in the Chvorinov's rule and the resistance offered, it may be concluded that the relative freezing time to complete solidification, when the riser freezes at the same rate as the casting, is unity when the riser has the same shape as the casting, and when the resistance offered by the dendrites and eutectic cells during solidification is zero. As explained before, Caine's equation (equ. 5) is a restatement of Chvorinov's rule taking into account the shape factor.

The resistance factor can also be taken into account by varying the value of c for different metals and foundry conditions as the resistance offered by dendrites and eutectic cells formed during solidification varies. Thus, the general equation for riser (equ. 9) is a restatement of Chvorinov's rule taking into account the shape factor and the resistance factor.

Steel freezes forming dendrites. For steel $c = 1.25$, from the data obtained by Bishop and others.[4] Therefore, $b = \frac{1.25}{25} = 0.05$ (equ. 6). For an alloy or metal forming no dendrites or eutectic cells during freezing, $c = 1$ (but no such metal exists). Therefore, $b = \frac{1}{25} = 0.04$. The values b and c for alloys forming dendrites, e.g., steel, and for gray and nodular iron are plotted against the area of dendritic mushy zone between 2 and 3 in. form the interface (to avoid chilling due to end effect), the areas being taken from the solidification diagram obtained by workers at Naval Research Laboratory,[7,8,9] for steel, gray iron and nodular iron (Figs. 12a, 12b). In gray iron, the coefficient of resistance (c) and

solidification shrinkage (b) are consistently less than those for dendritic alloys. The curves for gray iron, when produced, intersect the dendritic alloys curves at c = 1.55 and b = 0.062 which roughly corresponds to carbon = 2.3 per cent and silicon = 1.5 per cent (Figs. 12c, 12d). From the Maurer[17] diagram, we find this is mottled iron.

The curves of nodular iron intersect the dendritic alloys curve at c = 1.25, b = 0.05 which roughly corresponds to carbon = 3.17 per cent, silicon = 2.5 per cent or C.E. = 4. This means that at the point of intersection, gray iron (C.E. = 2.8) and nodular iron (C.E. = 4) have self-feeding just enough to compensate for the eutectic resistance to the passage of metal from the riser to the casting. On the right of the point, self-feeding is insufficient to compensate for the eutectic resistance completely; on the left of the point, self-feeding compensates all the eutectic resistance and a part of dendritic resistance.

The values of *b* and *c*, for gray and nodular iron, are plotted against carbon equivalent and percentage graphite by weight (Figs. 12c, 12d, 12e, 12f). It is evident that for a given carbon equivalent, the values of *b* and *c* are higher for nodular iron; but for a given per cent graphite, the values of *b* and *c* are higher for gray iron. This means that gray iron will precipitate more graphite, for a fixed carbon content than nodular iron, but the graphite in the nodule form has far more effective self-feeding than the flake graphite.

CONCLUSION

In this study, an analytic method is formulated to determine size and shape of risers. It may be used for any metal or alloy under certain restrictions and assumptions. It does not answer the questions of how many and where, but it does answer the questions what diameter and how high using the general equation (10),

$$\frac{25(4p+1)}{S_e} = \frac{p \cdot D}{b \cdot V_c} - \frac{1.275}{nD^2} \qquad (10)$$

Also, an attempt was made to explain the meaning of the constants *a*, *b* and *c* in Caine's equation for steel risers. A relationship was found between these constants and the equation restated in terms of constant *b*, which is solidification shrinkage of the metal at pouring temperature.

ACKNOWLEDGMENTS

To Prof. J. F. Wallace, Case Institute of Technology, whose technical advice and experience were of great help in research and preparation of this study. Also, the author is deeply indebted to the management of Larson Foundry, Grafton, Ohio, for their financial sponsorship and cooperation. The research and experimental work for the study were done at Larson Foundry in summer of 1957. Most of the contents of the paper are from the thesis submitted by the author at Case Institute of Technology as a partial fulfilment for M.S. in Industrial Engineering.

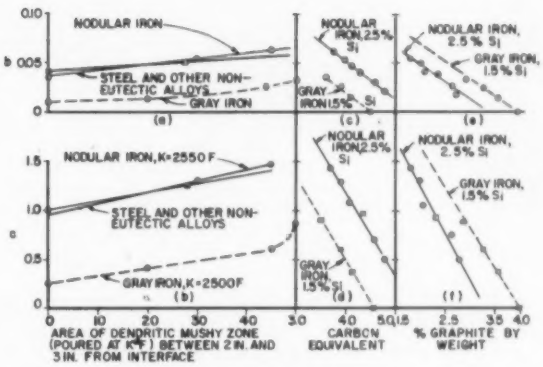
NODULAR IRON
STEEL AND OTHER NON-EUTECTIC ALLOYS
GRAY IRON
NODULAR IRON, 2.5% Si
GRAY IRON, 1.5% Si
NODULAR IRON, K=2550 F
GRAY IRON, K=2500 F
AREA OF DENDRITIC MUSHY ZONE (POURED AT K°) BETWEEN 2 IN. AND 3 IN. FROM INTERFACE
CARBON EQUIVALENT
% GRAPHITE BY WEIGHT

Fig. 12 — Relationship between mushy zone, constants *b* and c, C.E. and per cent graphite. The values of *b* and *c* for alloys forming dendrites (steel and nodular iron) are plotted against the area of dendritic mushy zone between 2 and 3 in. from the interface, the areas being taken from reference data[7,8,9] for steel and nodular iron (a and b). *c*, *d*, *e* and *f* are plotted against C.E. and percentage graphite by weight.

APPENDIX A

Solidification Shrinkage in Gray and Nodular Iron

The solidification shrinkage for any composition of gray iron poured at 2500 F, and nodular iron poured at 2550 F, can be found readily by the following methods:

Nodular Iron:[6] Figure 13 shows a curve of solubility of carbon in austenite of 2100 F. Carbon and silicon percentages of the metal being known, the percentage graphite by weight can be determined. Per cent graphite by volume is per cent graphite by weight divided by 0.3.

Figure 14 shows relation between per cent graphite by volume and solidification shrinkage of nodular iron, poured at 2550 F, for green and dry sand molds. It should be noted that there is a difference of about 1½ per cent shrinkage in green and dry sand molds. This is mainly due to mold wall movement.

Gray Iron:[18] The solidification shrinkage for gray iron poured at 2500 F in dry sand molds is given by,

$$\text{Total Shrinkage} = 200 = \frac{100}{1+16.5\times10^{-6}\times \text{F.R.}} \left(\frac{100-3.9}{100-Y}\right) [3.3(C-Y) + (100-C)]$$

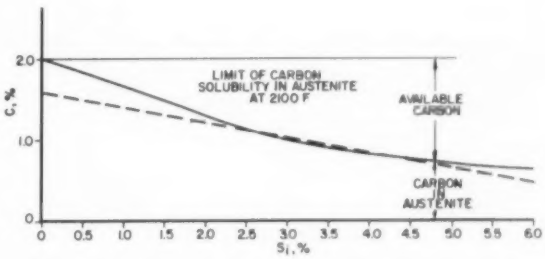

Fig. 13 — Solubility of carbon in austenite curve at 2100 F, from reference data.[6]

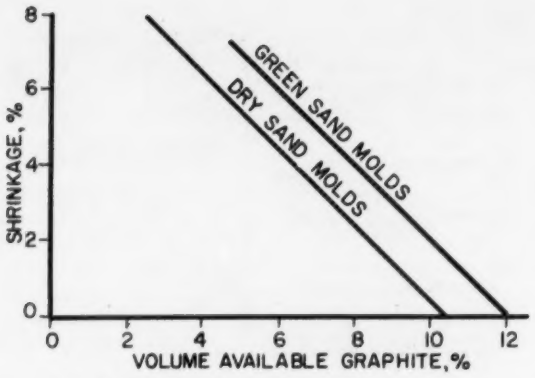

Fig. 14 — Comparison of shrinkage in green and dry sand molds for different amounts of available graphite, from reference data.[6]

where:

F.R. = freezing range, i.e., liquidus to eutectic temperature.

16.5×10^{-6} = average volumetric coefficient of expansion for liquid metal and austenite.

3.9 = Percentage shrinkage associated with the solidification of austenite.

C = per cent carbon.

Y = per cent carbon soluble in austenite.

3.3 = ratio of density of austenite to the density of graphite.

4.3 = per cent carbon in eutectic iron carbon alloy.

Schmidt and Taylor[10] found the difference in shrinkage in green and dry sand molds about 1.5 per cent.

The freezing range (F.R.) can be found in the formula by the following equations:

Freezing range F = Liquidus temp. F − 2050 where, 2050 = average eutectic temp. (F) and liquidus temp. F = 2981−218 F,[19] where, F = %C+½%P+¼%Si.

APPENDIX B

A Proposed Method for Risering Casting of Different Metals

From the solidification diagrams for different metals obtained by the research workers at Naval Research Laboratory, [7,8,9,15,20,21,22] and using the Fig. 12a, the values of solidification shrinkage for different metal are obtained and tabulated in Table 6.

Substituting the value of b in equation (9) gives the riser equation for any metal. For example, 99.9 per cent copper poured at 2050 F has a riser equation (when D = H, b = 0.04),

$$\frac{1}{S_c} = \frac{0.2D}{V_c} - \frac{0.0102}{D^2}$$

The following recommendations are suggested for top-insulated risers:

1) Try to obtain directional solidification in the casting.*
2) Place the riser in thickest section of the casting.

TABLE 6 – SOLIDIFICATION SHRINKAGES FOR DIFFERENT METALS

Metal Composition, %	Solid Shrinkage, %	Remarks
Aluminum 99	5.7	
0.08 C Steel	4.5	0.5% Si, 0.7% Mn, P.T.=2900 F
0.30 C Steel	4.7	0.5% Si, 0.7% Mn, P.T.=2900 F
0.60 C Steel	5	0.5% Si, 0.7% Mn, P.T.=2900 F
Copper 99.9	4	P.T.=2050 F
8.5 Mg - Al	6.2	P.T.=1200 F
4.5 Cu - Al	6.5	0.22% Si, P.T.=1250 F
Bronze (88-10-2)	6.5	P.T.=1900 F
Brass (60-40)	4.5	0.63% Sn, 0.51% Mn, 0.70%, P.T.=1779 F
Stainless Steel (12Cr)	3.13%	C, 2.7% Ni, P.T.=2950 F
Stainless Steel (18-8)	3.20%	C, P.T.=2800 F
Monel	3.14%	C, 6.2% Fe, 0.65% Si, P.T.=2500 F
Lead	3.5%	Cu, 0.5% Sn, P.T.=650 F

3) Neckdown the riser for easy removal from the casting and to avoid hot-spot at the junction of casting and riser.
4) Establish the proper H/D ratio feasible so as to need minimum riser weight.
5) Insulate all the risers at the top.
6) Use exothermic compounds in the riser for castings above 500 lb. A few dollars worth of exothermic compound can save the whole casting worth hundreds of dollars.
7) H/D ratio for light metal alloy should be more than one to obtain a proper hydrostatic pressure for the flow of metal from the riser to casting.
8) Do not use exothermic compounds in the metals where the extra heat generated by the compound promoted oxidation and drossing of the metal. Such metals are aluminum and magnesium alloys.

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*Directional solidification does not necessarily assure soundness. Depending on the geometery of the casting, a minimum gradient condition in excess of that required for directional solidification may be necessary for feeding to soundness,[10,24] e.g. 6 F per in. of gradient for bars[24] and 1 F per in. for plates.[2]

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MOLD MATERIAL EFFECT ON COOLING RATE AND PHYSICAL PROPERTIES OF CAST METALS

Second Report of Sub-committee T.S.46
of the Technical Council, Institute of British Foundrymen

ABSTRACT

The investigation started ten years ago as a result of some members of the technical council doubting the efficacy of the craftsman's practice of using raw red sand on bosses and junctions of thick and thin sections to prevent sinking in gray iron castings. This posed the question, "If it was effective in preventing sinking, why was it effective?" Basically, this was thought to be tantamount to asking "What is the effect of mold material on the solidification rate of cast metals?"

The original work was carried out with the interrupted-freezing or slush-casting method. This proved to be insufficiently sensitive and the investigation was then pursued with a pyrometric method. When certain precautions are taken this method is satisfactory and the general conclusions are that the coarser the sand the greater its cooling power and the harder a mold is rammed the greater its cooling power, other variables being equal.

The third stage of the work and the subject of the present report was to study the effect on the physical properties of various cast irons when cast into molds made in typical molding sands at various ramming densities, and also the effect when using other types of molding materials of varying thermal properties. The effect of inoculation and changing the volume to surface area ratio of the test bars was also investigated. Finally, a series of practical tests was carried out in four foundries, each engaged in different classes of work and using standard materials available in each foundry.

The results of the tests confirm the previous experimental work and show that increased coarseness of grain size and increased mold density increases tensile strength in all cases, when other variables are equal. The exception to this was found when the test casting was not of sufficient volume to avoid being mottled when the cooling power of the mold material was increased.

The conclusions reached in this report may assist in elucidating certain previously unexplained phenomena encountered in foundries. The report also sets out some variables which must be controlled when investigations into cooling rates of castings are being carried out.

The sub-committee T. S. 46 of the Institute of British Foundrymen is at present constituted as follows:

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Corresponding Member
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Secretary

PREVIOUS WORK BY THE COMMITTEE

Work started on this problem in March, 1947, the original investigation being carried out with the interrupted freezing or slush casting method, the idea being to measure the speed of movement of the solid-liquid metal interface away from the mold wall by slushing the casting a predetermined time after casting. This method proved to be insufficiently sensitive, as in all but pure metals and alloys freezing at a constant temperature, there exists a zone of partial solidification which produces a ragged surface to the shell formed in the mold after slushing. It was therefore not possible to determine the difference in cooling power of the different types of sand due to the existence of this zone of partial solidification between the all-solid and all-liquid regions.

Experiments were then carried out with a pyrometric method which consists of placing one or more thermo-couples in selected positions in the mold cavity, or molding sand, or both. Temperature changes were recorded with a sensitive temperature recorder from the moment of pouring the metal into the mold until solidification was complete. It was found that the results obtained had poor reproducibility. Further investigation showed that this was due to two main factors, one of which was the paramount importance of closely controlled mold density, and the other the fact that the cast iron used had a long freezing range and it was not possible to determine the exact end point of solidification.

An investigation was then carried out to find a satisfactory method of obtaining a mold of uniform density throughout its depth so that its density figure was correct at all positions in the mold and not an average of soft and hard areas. The method finally adopted was called the three-squeeze method and is described in the sub-committee's first report.[1]

To overcome the other cause of failure in reproducibility aluminium-bronze was used as the casting alloy. The tests showed that when poured at 1250 C

this alloy had approximately the same solidification time as cast iron.

The conclusion[1] drawn from the investigation into the suitability of the pyrometric method for studying the effect of sand mold materials on the solidification rate of cast metals was that it is satisfactory provided the following precautions are taken:

a) The casting must be sufficiently large to give a reasonable solidification time.
b) Sand bulk density and moisture content must be accurately controlled.
c) Gating and pouring temperature, including superheating temperature of metal, must be standardized.
d) Casting flash must be eliminated.

The sub-committee then carried out work on the effect of mold material on the cooling rate of cast metals using the pyrometric method and observing the foregoing precautions. From this work the following main conclusions were drawn:

1) The cooling power of the sand mold increases with increased ramming density for all sands investigated.
2) The coarser the grade of sand the greater its cooling power.
3) The cooling power of green sand is greater than that of dry sand and the addition of coal dust to either further increases the chilling power but this is more pronounced at low ramming densities.

WORK PROGRAM COVERED BY PRESENT REPORT

The salient feature to emerge from the discussion on the first report by the sub-committee was a need to produce some practical evidence of the physical effect on castings of varying the mold material and the density of the mold. In consequence, the technical council gave the sub-committee the following extended terms of reference:

> "To examine the effect of molding materials on the cooling rate of cast iron, and the resulting influence on physical properties."

It was agreed that the work should, in addition to the normal sands, include the following as mold materials: Shell molding materials; silicon carbide; oil sand; graphite; sodium-silicate bonded sand; zircon; olivine sand; and cement-bonded sand. It was also agreed that piston rings, valve guides and bars ½-in. to 1¼-in. dia. and 8 in. long be used as test castings.

The work covered in the present report falls into two groups as follow:

a) The work carried out by the Department of Industrial Metallurgy of Birmingham University under closely-controlled conditions, and
b) The work done by members of the sub-committee in their own foundries to ascertain if the results obtained at the University could be reproduced under production conditions.

Work Carried Out at University

This work consisted of tests using the following molding materials:

1) Natural-bonded Bromsgrove red sand with and without coal dust.
2) Coarse and fine grain size silica sands bonded with bentonite, cement, linseed oil and dextrine, and sodium-silicate.
3) Zirconium silicate and olivine sand bonded with bentonite.
4) Two grades of graphite each bonded with linseed oil and dextrine and sodium-silicate.
5) Shell process molds in Redhill 'H' and Leighton Buzzard sands.
6) Silicon-carbide bonded with sodium-silicate or with bentonite and subsequently vitrified.

Eight per cent coal dust was added to the bentonite-bonded sands to improve casting finish. The grades used are listed in Table 2.

Round test bar castings of various diameters were made in each of the mold materials described in the foregoing. The mold and gating systems are shown in Fig. 1. The bars were cast ½-in., ¾-in., 1-in., and

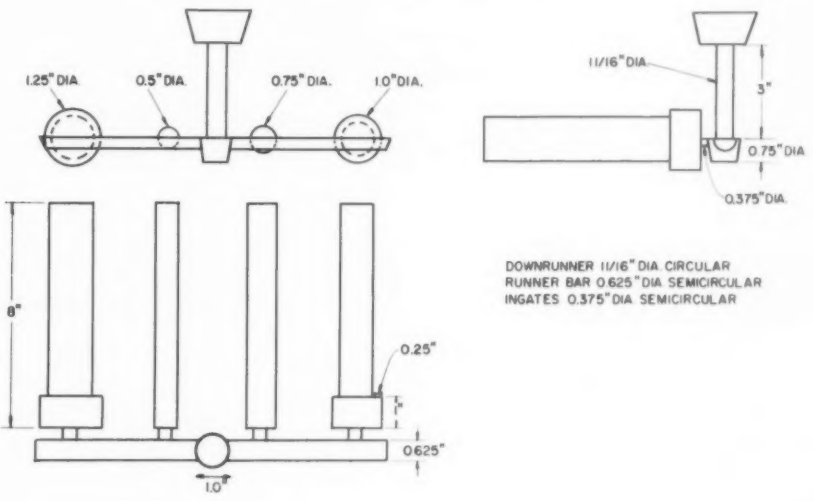


Fig. 1 — Mold layout and gating system as used at the University (results given in Table 2).

TABLE 1 – ANALYSIS OF IRONS OF VARIOUS CARBON EQUIVALENTS USED AT THE UNIVERSITY
(analysis of all the melts was within the following limits)

Iron		Composition, %									
Mark	Nominal carbon equivalent	T.C.	±	Si	±	P	±	Mn	±	S
J.	4.2	3.30	0.04	2.44	0.04	0.21	0.03	1.40	0.03	0.01
K.	4.5	3.51		2.96		0.20		1.38		0.01
L.	3.7	2.93		2.16		0.19		1.37		0.01
M.	3.7*	2.89		2.25		0.19				

*Inoculated with calcium silicide

1¼-in. dia. and 8 in. long; the gating system was of the choked type. Preliminary experiments showed that no feeders were necessary to produce sound ½-in. and ¾-in. bars, but small feeders were placed at the ingate ends of the 1-in. and 1¼-in. bars as shown in Fig. 1.

A test-bar casting was also designed with four square bars having the same volumes as the 1¼-in., 1-in., ¾-in. and ½-in. dia. bars. The length of these bars was 8 in. and the lengths of the sides 1.11, 0.89, 0.67, and 0.44 in. The square test-bar castings were machined to standard test-bar sizes for tensile strength testing.

The base iron used was refined pig iron containing C, 3.35%; Si, 2.22%; Mn, 1.3%; P, 0.3%; and sulfur 0.01%. This iron had a C.E. (carbon equivalent) of 4.2 (iron 'J') and to produce a nominal C.E. of 4.5 (iron 'K') an addition of 0.5 per cent silicon-carbide was made to the base iron. For the melt of nominal C.E. 3.7 (iron 'L'), an addition of 15 per cent of mild steel was made.

All the irons were superheated to 1450 C. The 4.2 C.E. iron 'J' was poured at 1350 C and the 3.7 and 4.5 C.E. irons 'K' and 'L' at 1375 C. High-frequency induction melting was used throughout and the temperatures measured by means of Pt-Pt.Rh couple and a direct-reading instrument.

The effect of carbon equivalent was investigated by making the round bar castings in Redhill 'H', Redhill 1½$_{28}$ and Bromsgrove sands with irons 'J', 'K' and 'L' of carbon equivalents of 4.56, 4.2, and 3.71, respectively. All melts were analyzed and the results are detailed in Table 1. The effect of inoculation with 0.5 per cent ferro-silicon,* 0.25 per cent of silicon carbide, and 0.25 per cent of calcium silicide, respectively, was studied with the iron of C.E. 3.6 (iron 'M').

Tests using Redhill 'H', Redhill 1½$_{28}$ and Congleton sand molds were also made with square bars to obtain data on the effects of the different sands on bars with different volume-to-surface-area ratios.

The work carried out in members' foundries as described in the following was also duplicated at the University to act as a check on the reproducibility of results.

All the various bars produced were machined to corresponding standard test bars and tensile tested. Brinell hardness readings were taken across the diameter of the 1¼-in. bars cast in coarse synthetic sand, natural sand, and zirconium-silicate molds bonded with bentonite.

In addition to the tensile testing of all bars, microexamination was carried out on transverse sections adjacent to the tensile fractures.

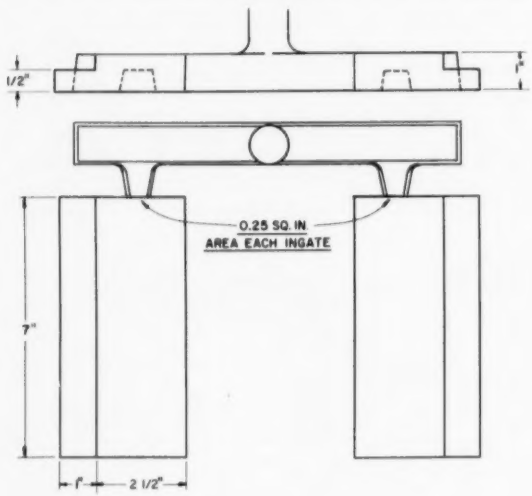
*Ferro-silicon 75 per cent silicon.

TESTS CARRIED OUT BY MEMBERS

Stepped Bar Castings

This work consisted of making the castings shown in Fig. 2 in four different foundries and at the University. The pattern and runner system were identical in each case and each foundry made two pairs of castings using coarse sand hard-rammed and fine sand soft-rammed. Each investigator used the coarsest sand and the finest sand available in his foundry, except that at the University the original sands already referred to were used and at one foundry only one type of natural sand was available.

In this latter case the same type of sand was used in each mold, one mold being rammed hard and one soft. All molds were hand-rammed, and the sand contained 8 per cent coal dust with a moisture percentage to suit molding conditions. The molds were made in a 4-in. deep molding box and cast in the typical gray



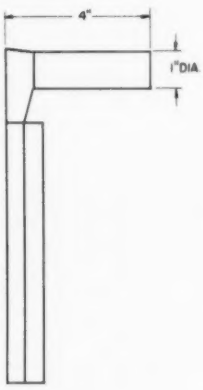


Fig. 2 — Step castings and runner system (results in Table 4).

iron available in each foundry. Two test bars, one from each outside edge of each test casting, were machined from the test block. The casting temperatures were read with an immersion pyrometer by the same investigator who visited each foundry when the castings were being made.

To supplement the tensile figures obtained from the test bars cast at the foundry which used only one type of natural sand, further work was carried out by two other member foundries who repeated their tests, one using Congleton base synthetic sand and the other Bromsgrove natural sand. In these tests the only variable was ramming density, each foundry making two test castings, one rammed hard and one soft. Similar tests were repeated at the University using one sand and extremes of ramming density.

TABLE 2 – DETAILS OF MOLD AND MOLD MATERIALS AND TENSILE STRENGTHS OBTAINED ON ROUND TEST BARS WITH IRON OF C.E. 4.2 MARK 'J' USED AT THE UNIVERSITY

Mold Material	Grain Size	Density g/cc	Bond	Moisture, %	Drying treatment	Coal dust	Tensile strengths, tons per sq. in. Bar diameters, in. 1¼	1	¾	½
Leighton Buzzard(C)	Coarse	1.95	10% cement	10			15.9	18.5	21.2	mottled
Zirconium silicate	Very fine	2.61	3½% bentonite	3½		8% fine	15.7	18.2	20.8	24.8
Olivine	Coarse – medium	1.82	3½% bentonite	4		8% med.	15.6	17.7	20.0	24.4
Leighton Buzzard(C)	Coarse	1.72	Oil[a]		8 hr 200 C		15.6	18.0	20.8	mottled
Redhill 14/28	Coarse	1.62	3½% bentonite	3		8% Coarse	15.5	17.6	20.4	25.0
Redhill H	Fine	1.70	10% cement	10			15.2	17.5	20.0	24.4
Redhill H	Fine	1.60	Oil[a]		8 hr 200 C		15.1	17.2	19.8	23.5
Leighton Buzzard(C)	Coarse	1.65	CO_2 5%				15.0	17.4	20.2	mottled
Bromsgrove black	Medium	1.52	clay approx. 11%	7		8% med.	14.9	16.7	19.9	24.0
Redhill H	Fine	1.56	CO_2 5%				14.6	16.5	19.0	23.0
Leighton Buzzard (22)	Fine	Shell 0.5 in. thick	6% resin				14.5	16.0	18.2	22.0
Redhill H	Fine	1.31	3½% bentonite	4		8% fine	14.4	16.1	18.9	23.0
Redhill H	Fine	Shell 0.4 in. thick	6% resin				13.7	15.3	17.7	21.5
Graphite B.B.5. coarse	50% thru 35 onto 65 mesh	1.06	oil[b]		8 hr 200 C		15.0	19.9		
Graphite G.10 fine	90% thru 100 55% thru 200 mesh	1.06	oil[b]		8 hr 200 C		15.1	20.1		
Graphite B.B.5. coarse	50% thru 35 onto 65 mesh	1.06	CO_2 10%				14.5	18.8		
Graphite G.10 fine	90% thru 100 55% thru 200 mesh	1.06	CO_2 10%				14.8	19.2		
Silicon carbide	Medium	1.90	2% clay	2	vitrified 1300		16.9	mottled		
Silicon carbide	Coarse	1.90	2% clay	2	vitrified 1300		16.8	mottled		
Silicon carbide	Medium	1.90	2% clay	2	8 hr 200 C		15.9	mottled		
Silicon carbide	Coarse	1.90	2% clay	2	8 hr 200 C		15.8	mottled		

[a]1% linseed oil, 1½% starch. [b]4% linseed oil, 2% starch. All values the mean of at least two results.

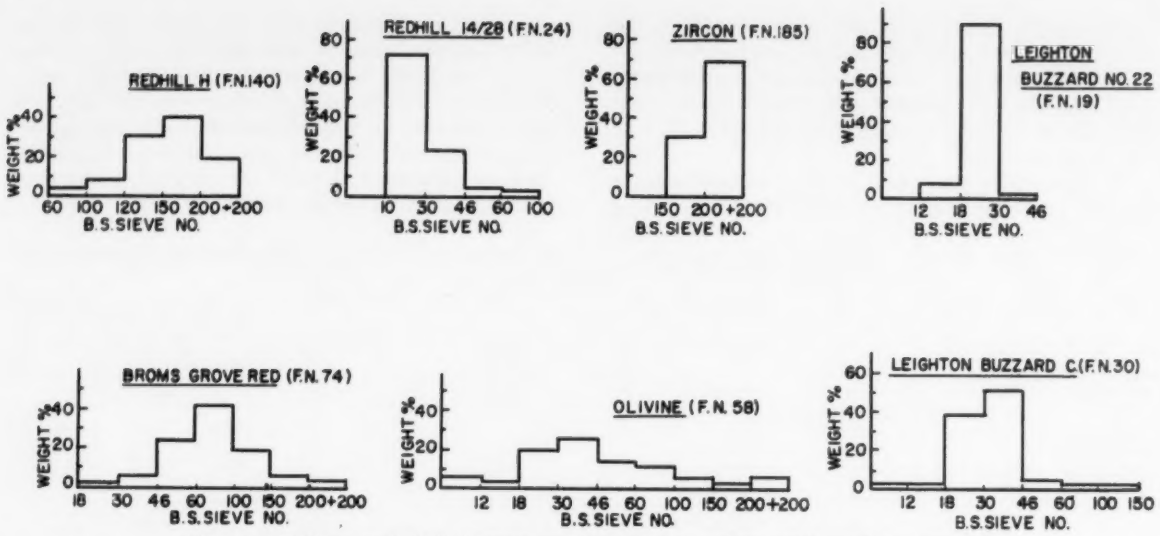


Fig. 3 — Gradings and AFS fineness numbers of the various sands used for work recorded in Table 2 (typical sand analyses are given in Table 3 of the first report[1]).

Piston Rings and Valve Guides

A series of tests was also made by a member of the sub-committee using valve guides and piston rings as test castings to determine the effect of various mold materials upon the physical properties and microstructure of the castings. The tests were carried out under standard production conditions and standard ramming densities.

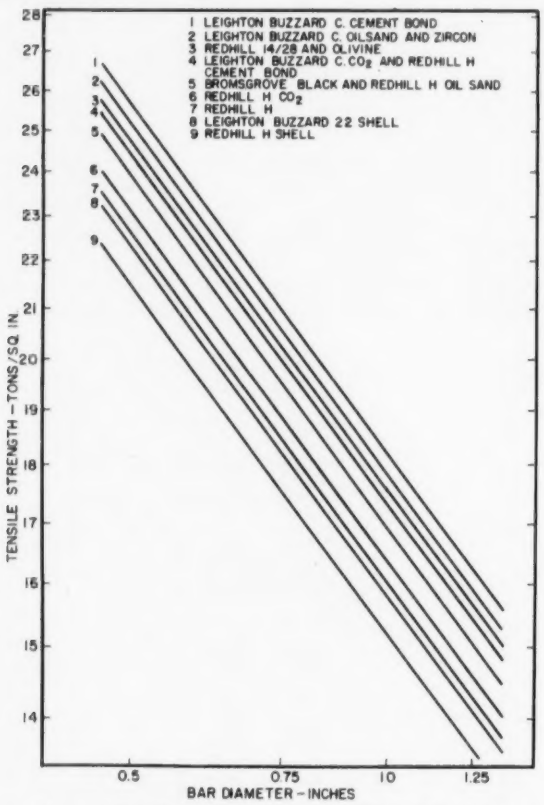

1 LEIGHTON BUZZARD C. CEMENT BOND
2 LEIGHTON BUZZARD C. OILSAND AND ZIRCON
3 REDHILL 14/28 AND OLIVINE
4 LEIGHTON BUZZARD C. CO_2 AND REDHILL H CEMENT BOND
5 BROMSGROVE BLACK AND REDHILL H OIL SAND
6 REDHILL H CO_2
7 REDHILL H
8 LEIGHTON BUZZARD 22 SHELL
9 REDHILL H SHELL
TENSILE STRENGTH – TONS/SQ. IN.
BAR DIAMETER – INCHES

Fig. 4 — Tensile results of iron J (C.E. = 4.2) plotted against bar diameter.

EXPERIMENTAL RESULTS

Program of Work at the University

Sand molds. The results are set out in tabular form in Table 2 with details of the various sands and other molding materials used. The gradings of the sands are given in Fig. 3. The variation of tensile strength with mold material of the iron 'J' of C.E. 4.2 is shown in Fig. 4. The results are plotted in logarithmic coordinates and a common slope selected such that when lines of this slope were passed through the experimental points there was the least deviation.

The actual tensile values obtained are given in Table 2. The minimum tensile properties were obtained in the bars cast into Redhill 'H' shell molds, the maximum properties, approximately 20 per cent greater, in the bars cast into cement-bonded Leighton Buzzard 'C' sand. The bars produced were gray with the exception of those of ½-in. dia. cast into Leighton Buzzard cement- and oil-bonded sands. Figure 5 sets out the Brinell numbers obtained from zircon sand, Bromsgrove black and Redhill 'H' in graph form, and Fig. 6 shows the tensile stength and Brinell hard-

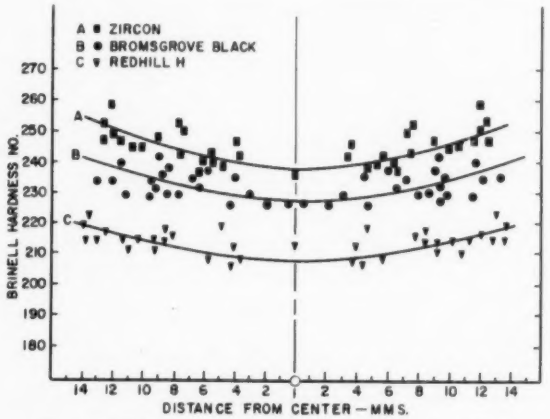


Fig. 5 — Brinell hardness numbers of iron J (C.E. = 4.2) bar diameter 1¼-in. As cast.

ness of the bars cast into Redhill 'H' and zircon sands bonded with bentonite.

Silicon Carbide and Graphite

The molds used in this series of experiments were poured vertically. Two bar diameters, 1¼ and 1 in., were chosen and the bar length was 8 in. Two grades of silicon carbide, medium and coarse, were used as mold materials. One series of molds was vitrified at 1300 C and another baked at 200 C for 8 hr. Both coarse and fine grades of graphite were studied. The graphite was bonded with either sodium silicate or an oil bond. Details of both the silicon carbide and graphite molds are given in Table 2. The iron 'J' in these experiments was of nominal C.E. 4.2 and the iron, superheated to 1450 C, was poured vertically into the molds at 1350 C. The tensile results obtained from the bars was given in Table 2.

Moisture

The Redhill 'H' and Redhill $1\frac{1}{28}$ bentonite-bonded and the Bromsgrove clay-bonded sands were studied in both green and dry conditions. The molds were dried by baking at 200 C for 8 hr. It was found that the moisture did not exert an appreciable effect upon the tensile strength of the iron of C.E. 4.2 cast into these molds.

Coal Dust

The Redhill 'H' and Redhill $1\frac{1}{28}$ bentonite-bonded and Bromsgrove clay-bonded sands were studied in the green condition both with and without the addition of 8 per cent coal dust. It was found that the coal dust showed no appreciable effect upon the tensile strength of the iron of C.E. 4.2 cast into these molds.

Inoculation

The effect of inoculation was studied only in Bromsgrove black sand and in ½-in., ¾-in., 1-in., and 1¼-in. diameter bars. The inoculants were introduced into the ladle prior to tapping, the degree of superheat being 1450 C and pouring temperature 1375 C. Figure 8 shows the effect of calcium-silicate in a C.E. 3.71 iron.

Irons of Various Carbon Equivalent

The results of the tensile strength tests on bars cast in irons 'J', 'K', and 'L' are plotted against bar diameter and given in Fig. 9. All three irons were cast into molds made of Redhill 'H', Redhill $1\frac{1}{28}$ and Bromsgrove black, respectively.

Square Bars

The iron used was one with a C.E. of 4.2, and the results are given in Table 3, which gives actual results obtained in tons/in.^{2} on the four bars from the three sands to enable other forms of graph to be plotted as required. In Fig. 10 tensile strength is plotted against volume-to-surface area ratio for both round and square bars.

Effect of Superheating the Iron

The effect upon the mechanical properties of the iron 'J' C.E. 4.2 was studied. Bars were cast in bentonite-bonded Redhill 'H' and Redhill $1\frac{1}{28}$ green sand molds. The superheat temperatures were

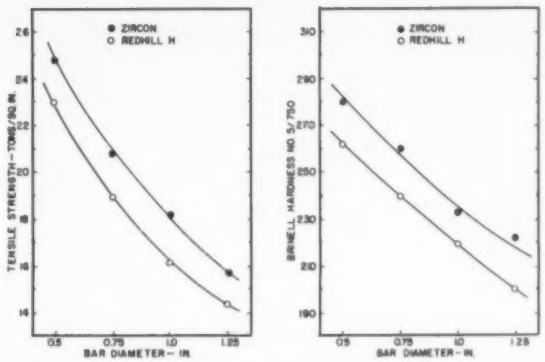
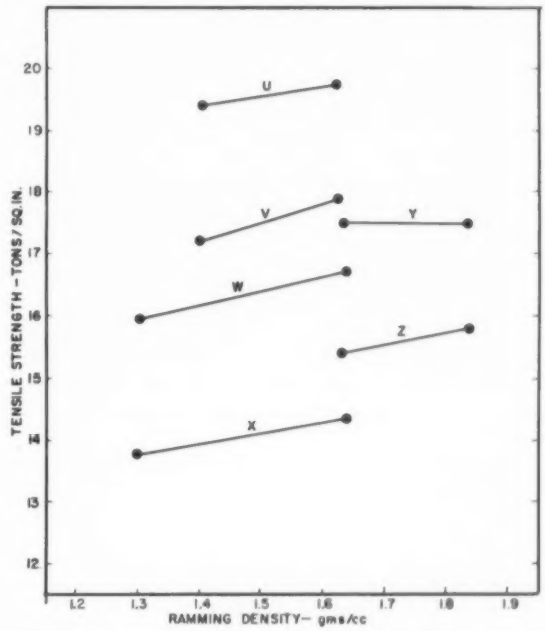


Fig. 6 — Tensile strengths and Brinell hardness numbers against bar diameters for iron J (C.E. = 4.2).

1550 C and 1350 C and the pouring temperature was 1340 C in both cases. The effect on the tensile strength is shown in Fig. 11. An increase in superheat from 1350 C to 1550 C with a constant pouring temperature of 1340 C, increases the strength of the 1-in. dia. bar by approximately 10 per cent in both sands.

Effect of Various Mold Materials and Section Size on Microstructures of Iron 'J' (C.E. 4.2)

The effect of section size and mold material upon the structure of the test bars of the iron of carbon equivalent of 4.2 only are considered as similar changes were observed in the other irons.



KEY:		Iron	Mold Material
		F	Bromsgrove
U	½ in.		
V	1 in.		
W	½ in.	G	Congleton
X	1 in.		
Y	½ in.	H	Bromsgrove
Z	1 in.		

Fig. 7 — Ramming density effect on tensile strength of test bars from step bar castings.

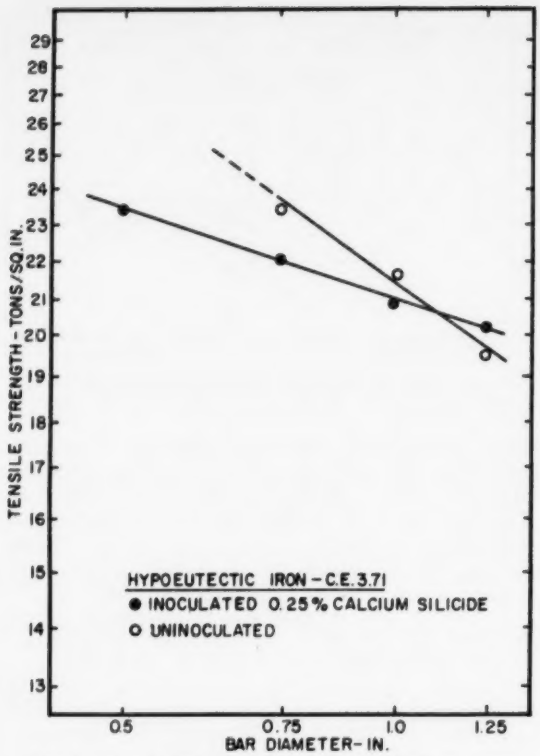


Fig. 8 — Inoculation by calcium-silicide effect on irons L and M (C.E. = 3.71).

Since the pouring temperature and degree of superheat were kept constant, any changes in structure are related to changes in cooling rate due to changes in either section size or mold material.

1) Section size.

The microstructures at the centers of the bars cast into Redhill 'H' green-sand molds have been considered in detail, and the unetched microstructures of these specimens are shown in Figs. 12a-12d.

Both the graphite type and flake size vary with section size, the 1¼-, 1-, and ¾-in. dia. bars all show types A and B graphite, the main difference between these specimens being in the rosettes, which show a dendritic pattern in the ¾- and 1-in. bars. In the ½-in. dia. bar the graphite is mainly type D.

At each section size the matrix structure is essentially pearlitic, although free ferrite tends to be associated with the undercooled graphite present in the ½-in. dia. bar.

Section size has an appreciable effect upon the distribution of the eutectic phosphide. In the ½-in. dia. bar this eutectic forms a network around the eutectic cells. With a slower cooling rate (¾-in. dia. bar) the eutectic phosphide tends towards a more random distribution, and in the 1- and 1¼-in. dia. bars it has a completely random distribution. This change from the random to a network distribution is shown in Fig. 12e-12f, and where the distributions of eutectic phosphorus in 1¼- and ½-in. dia. bars are shown.

The variation of eutectic cell number with bar diameter is shown in Fig. 12g, where the number of eutectic cells per cm at the center of a bar is plotted against bar diameter. The eutectic cell size decreases as the section size decreases, i.e., as the cooling rate increases.

2) Mold material.

The effect of mold material upon the tensile strength of a gray iron may be related to changes in structure. Considering the iron of carbon equivalent 4.2 the microstructures at the centers of the 1- and ½-in. dia. bars cast into the molds giving the maximum and minimum tensile results, Leighton Buzzard cement and Redhill 'H' shell, are shown in Figs. 12h-12k. These show that mold material can exert an appreciable effect upon both the types and flake size of the graphite, and in the case of the ½-in. dia. bars whether the iron is gray or mottled.

Work on Stepped Bar Castings

The details and results of the tests to determine the effect of mold material and ramming density upon the tensile strength of a rectangular stepped casting are shown in the following tables and figures:

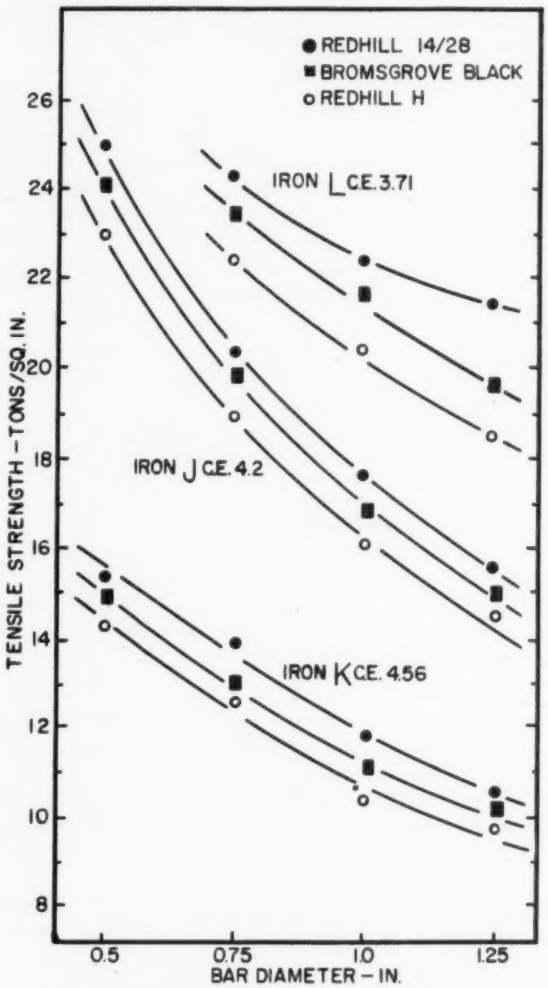


Fig. 9 — Relationship between mold material, carbon equivalent value, tensile strength and bar diameter.

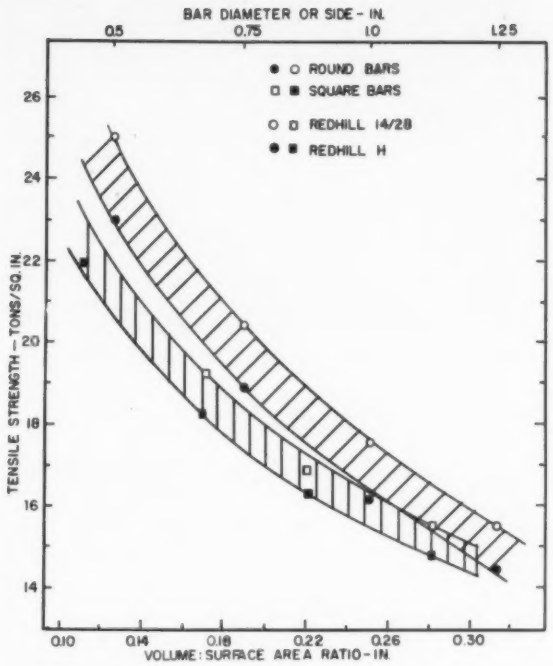


Fig. 10 — Tensile strength of round and square bars plotted against volume/surface area ratio.

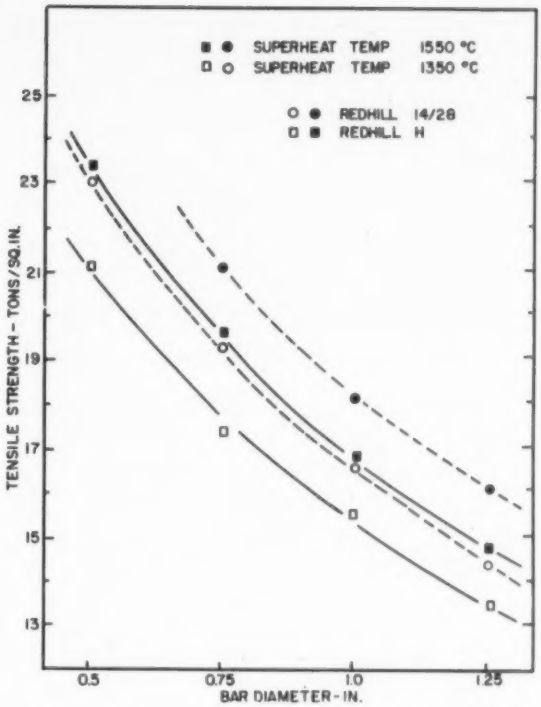


Fig. 11 — Degree of superheat effect on the tensile strength of iron J (C.E. = 4.2) cast into Redhill 14/28 and Redhill H green sand molds.

Fig. 12a — 1¼-in. diameter bar.

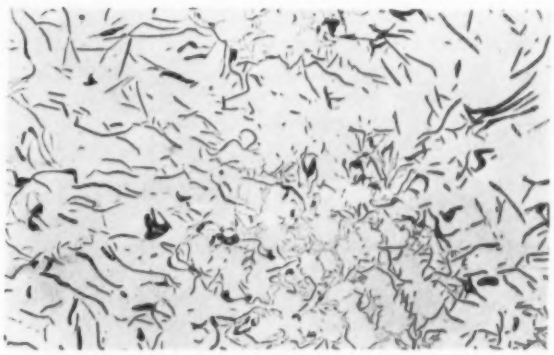


Fig. 12b — 1 in. diameter bar.

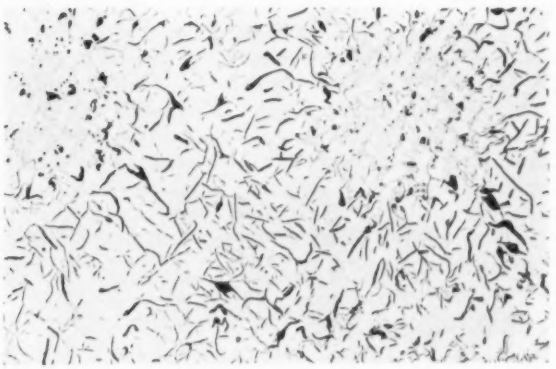


Fig. 12c — ¾-in. diameter bar.

Fig. 12d — ½-in. diameter bar.

Fig. 12 a-d — Microstructures at the centers of 1¼, 1, ¾ and ½-in. diameter bars of iron J (C.E. = 4.2), cast in Redhill H bentonite bond green-sand molds. Unetched. 60 ×.

Fig. 12e — Random distribution of eutectic phosphide in 1¼-in. diameter bar.

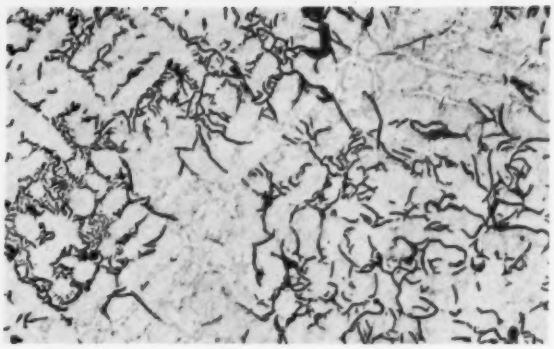


Fig. 12f — Network of eutectic phosphide in ½-in. diameter bar.

Fig. 12 e-f — Influence of cooling rate on the distribution of eutectic phosphide in bars of iron J (C.E. = 4.2) cast in Redhill H green-sand molds. 4 per cent Picral etch. 150 ×.

Table 4. Details of molds, mold material and tensile strengths obtained from 1-in. and ½-in. sections.

Table 5. Analysis of the irons used.

Figs. 13, 14 and 15 show the mean of the tensile values obtained plotted against ramming density for the 1-in. and ½-in. sections.

Experiments on Piston Rings and Valve Guides

This work was carried out to determine the effects of mold material at constant ramming density upon the physical properties and microstructure of cast iron piston rings and valve guides.

It was decided that as far as possible all test castings should be made by standard production methods, except that special care should be taken in presenting a given weight of sand to each box to ensure mold uniformity. Each box was subjected to a standard ramming or squeeze in an effort to obtain uniformity of mold density.

The analysis of the iron used in the experiments and degree of superheat and casting temperature are given in Table 6. Molds nos. 1 and 2 were made on a jolt-squeeze-draw machine, and nos. 3, 4, and 5 were made on an electromagnetic-squeeze-draw machine. Melting for molds nos. 1, 2 and 3 was carried out in a 600-lb indirect rocking arc furnace. Molds nos. 4 and 5 were cast in cupola-melted iron superheated in a mains-frequency furnace. Mechanical testing was carried out by machining a 0.178-in. dia. tensometer test piece from the bottom face of the valve guides. Piston rings were tested for En* and tensile strength by British Standard methods. Hardness tests were carried out on the bottom face of the valve guides and at 90° intervals round the diameter. Molding sands consisted of four different sands, details of which are given in Table 7.

The results obtained from the first series of tests with uniform ramming density are also given in Table 7. The second series in which an attempt was made to vary the ramming density under production conditions is set out at the bottom of Table 7. As will be seen, it was not possible to get a wide variation in ramming density, as soft molds would not stay in the shallow molding box.

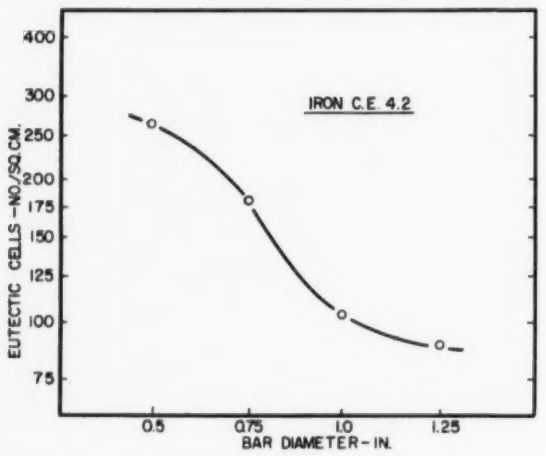


Fig. 12g — Variation of eutectic cell size with bar diameter. Iron J, Redhill H green-sand molds.

DISCUSSION OF RESULTS

Effect of Various Mold Materials on Mechanical Properties of Cast Bars

When melting variables are constant the mechanical properties of a given cast iron should be affected only by the cooling rate. Under the conditions of the experiments, the cooling rate is controlled by 1) thermal properties of the mold material, and 2) the size of bars. The difference in solidification times of castings due to these two factors may be calculated. Consider first the mold materials. It has been shown[2] that when the corner and surface curvature effects are neglected, the solidification time of a casting in a particular metal or alloy should be approximately proportional to $1/b^2$ where 'b' is the heat diffusivity.

*Modulus of elasticity determined on ring test piece, B.S. 5004.

TABLE 3 – TENSILE STRENGTH OF SQUARE BARS IN TONS/SQ. IN.

Length of side, in.	Volume-surface area ratio, in.	Redhill 14/28	Congleton	Redhill H
1.11	0.28	15.5	15.3	14.8
0.89	0.22	16.8	16.4	16.2
0.67	0.17	19.2	18.9	18.2
0.44	0.11	mottled	22.4	21.9

Fig. 12h — Redhill H shell mold. Unetched.

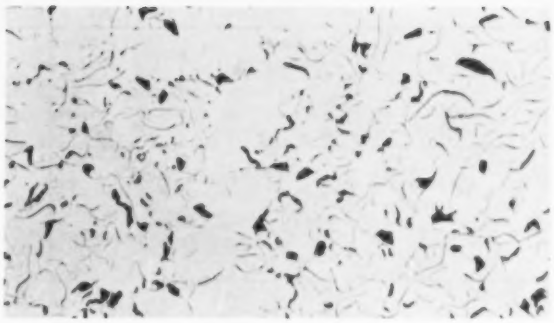


Fig. 12i — Leighton Buzzard C, cement bond. Unetched.

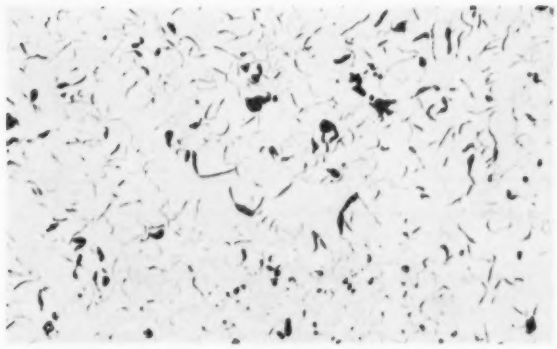


Fig. 12j — Redhill H shell mold. Unetched.

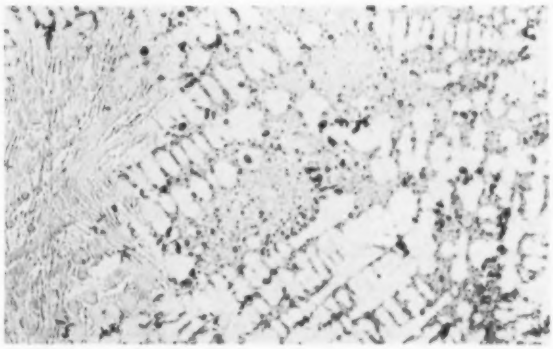


Fig. 12k — Leighton Buzzard C, cement bond. 4 per cent Picral etch.

Fig. 12 h-k — Mold material effect on structure of 1 in. diameter bar cast in iron J (h,i), and of ½-in. diameter bar cast in iron J (j,k). 100 ×.

Reference to the earlier work of the sub-committee[1] and the values of b[2] recorded there for two extreme sands, Redhill $1\frac{4}{28}$ and Redhill 'H', reveals that the solidification time of the fine sand rammed soft is approximately 1.8 times that of coarse sand rammed hard. In the case of bars of different size, Chvorinov's[10] rule may be used to calculate approximately the relative solidification times. Considering the ½-in. bar and the 1¼-in. bar, the solidification time of the 1¼-in. dia. bar is approximately 5½ times that of the ½-in. dia. bar.

From the results obtained in the experiments described, it will be seen that the effect of mold material on the physical properties of the cast iron is in line with the cooling rate of the iron which is mainly increased by an increase of 1) the grain size of the sand, and 2) the ramming density of the mold.

It has been shown[1,3] that the heat removed in a given time by a dry sand mold is proportional to the difference between the temperature of the metal/mold interface and the initial mold temperature, and the heat diffusivity 'b,' which may be expressed as

$$b = \sqrt{(kpc)}$$

where

k = apparent thermal conductivity of mold
p = density of mold
c = specific heat of mold

The term "apparent thermal conductivity" is used, as heat transfer in a sand mold may take place in several ways,[4,5,6] part of it being transferred by a true solid conduction mechanism, and part by radiation of heat between and through the sand grains.

In the present work the metal mold interface and initial mold temperature are nominally constant, and so to explain the different cooling powers of the different mold materials, differences in heat diffusivities of the materials must be considered. In this work there are five variables of which to take account, namely:

a) Physical and chemical properties of the mold material.
b) Grain size of the material.
c) Ramming density of the mold.
d) Bonding material.
e) Moisture content of the mold.

Physical and Chemical Properties of Mold Material

Both specific heat and density are terms in the equation expressing heat diffusivity, and so it is to be expected that the cooling power of a mold will depend upon these two properties of the mold material.

The thermal conductivity of the mold material would exert an influence upon the apparent thermal conductivity of a mold compact, as would the opacity of the material to heat radiation.

TABLE 4 – DETAILS OF MOLDS AND MOLD MATERIALS USED IN MAKING STEP CASTINGS, AND TENSILE STRENGTH OF TEST BARS OBTAINED FROM STEP CASTINGS

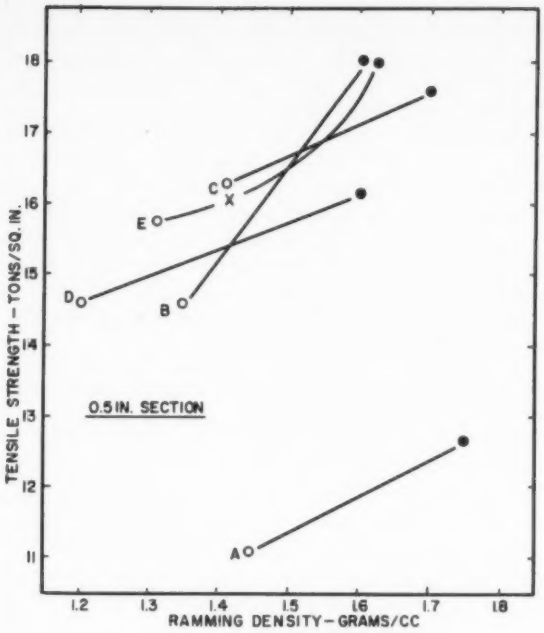
Iron and Casting Temp., C	Mold material	Sand grading, % on 60 mesh	Sand grading, % thru 60 mesh	Sand Properties: Green Comp. lb/in.²	Sand Properties: Green Perm.	Sand Properties: Shatter No.	Mold details: Moisture, %	Mold details: Bond	Mold details: Coal Dust	Mold details: Density g/cc	Tensile strength tons/sq in.: 1 in. Sect.	Tensile strength tons/sq in.: ½-in. Sect.
A										1.75	10.1	12.6
1350	Bromsgrove	31	59	7.5	24	52	5.5	Natural Clay	yes		9.6	12.7
											8.8	11.3
										1.45	8.8	11.0
B											15.5	18.2
1428	Hensall	93	7	9.6	68	83	7.6	Added Clay	yes	1.61	15.3	17.8
	Erith Loam and Ryarsh	1.5	98.5	13	23	61	3.0	Natural Clay	no	1.35	13.2	14.2
											13.1	15.0
C								3%			15.0	17.4
1385	Queslett	77.8	22.2	2.2	500	—	3.0	Bentonite	8%	1.70	15.6	
												17.8
	Kingscliffe	7.8	92.2	3.0	230	—	3.5	3% Bentonite	8%	1.41	14.4	16.6
											14.4	16.0
D								4%	8%		13.6	16.0
1390	Chelford	72.4	27.6	6.4	166	90	3.6	Added Clay	fine	1.6	13.8	16.2
	Congleton and Kings Lynn 4F	30.8	69.2	6.0	124	86	4.2	4½% Added Clay	8% fine	1.2	12.6	14.7
											12.4	14.5
E								3½%	8%		14.6	17.6
1350	Redhill 14/28	97.6	2.4	2.7	200		3.0	Bentonite	coarse	1.62	14.8	18.4
	Congleton	32.1	67.9	8.5	86	45	3.0	3½% Bentonite	8% medium	1.52	14.0	16.8
											14.0	16.6
	Redhill H	0.0	100	8.0	30	38	4.0	3½% Bentonite	8% fine	1.31	13.8	16.0
											13.6	15.5
Tests using one sand at extreme of ramming density												
F								Natural			17.9	19.7
1350	Bromsgrove	31	59	7.5	24	52	5.5	Clay	yes	1.62	18.0	19.8
										1.40	17.1	19.4
											17.3	19.4
G								3½%	8%		14.1	16.5
1350	Congleton	32.1	67.9	8.5	86	45	3.0	Bentonite	medium	1.62	14.5	16.9
										1.30	13.8	16.0
											13.7	15.9
H								Natural				
1380	Bromsgrove	31	59	7.5	24	52	3.0	Clay	yes	1.83	15.8	17.5
										1.63	15.4	17.5

TABLE 5 – ANALYSIS OF IRONS (STEPPED TEST CASTINGS) (Mold details given in Table 4)

Iron	Composition, % T.C.	Si	Mn	S	P	C.E.
Iron A	3.74	2.15	0.77	0.065	0.34	4.57
Iron B	3.43	1.87	1.13	0.057	0.066	4.07
Iron C	3.35	2.00	0.91	0.095	0.27	4.10
Iron D	3.42	2.11	0.50	0.111	0.59	4.32
Iron E	3.37	2.50	1.42	0.008	0.24	4.28
Iron F	3.11	1.66	0.42	0.10	0.26	3.75
Iron G	3.32	2.47	1.40	0.015	0.21	4.21
Iron H	3.42	1.80	0.82	0.087	0.18	4.08

TABLE 6 – ANALYSIS OF THE IRON FOR VALVE GUIDES AND PISTON RINGS WITH SUPERHEAT AND CASTING TEMPERATURE

Casting	Composition, % T.C.	Si	Mn	S	P	Temperature, C Superheat	Casting
1. Valve guide 3½ in. x 5/8 in. dia.	3.55	2.29	0.93	0.035	0.16	1440	1340
2. Valve guide 2 in. x 1 3/16 in. dia.	3.55	2.18	0.80	0.05	0.20	1430	1345
3. Valve seat	3.74	2.35	0.70	0.06	0.18	1430	1345
4. Piston ring	3.70	2.41	0.60	0.06	0.58	1640 + slot. bath 1500	1420
5. Valve plate	3.70	2.41	0.60	0.06	0.58	1640 + slot. bath 1500	1420



Ramming Density..	Soft	Medium	Hard
Symbol	O	X	●
Iron Used			
A	Bromsgrove		Bromsgrove
B	Erith and Ryarsh		Hensall
C	Kingscliffe		Queslett
D	Congleton and Kings Lynn		Chelford
E	Redhill H	Congleton	Redhill 14/28

Type of Sand Used

Fig. 13 — Mean tensile strength values for ½-in. diameter bars machined from step castings plotted against ramming density (results given in Table 4).

Grain Size of Material

Sand grain size affects the apparent thermal conductivity of a sand, an increase in the grain size increasing the apparent thermal conductivity, the heat diffusivity and so the cooling power of the sand. This increase in the thermal conductivity is attributable to three mechanisms. True thermal conduction across the junction between the sand grains, intergranular radiation, and transgranular radiation. Atterton[4] shows the importance of the last two at higher temperatures, which is in line with theoretical arguments.

Ramming Density of Mold

Mold density is one of the factors in the expression for the heat diffusivity, and so it is to be expected that an increase in the ramming density of a mold material produces an increase in cooling power of the material.

The true thermal conductivity of a sand aggregate will also increase as the compact density increases,[4] due to an increase in the area of contact between the sand grains.

Bonding Material

If ramming density is plotted against tensile strength for the bars of different diameters, cast in

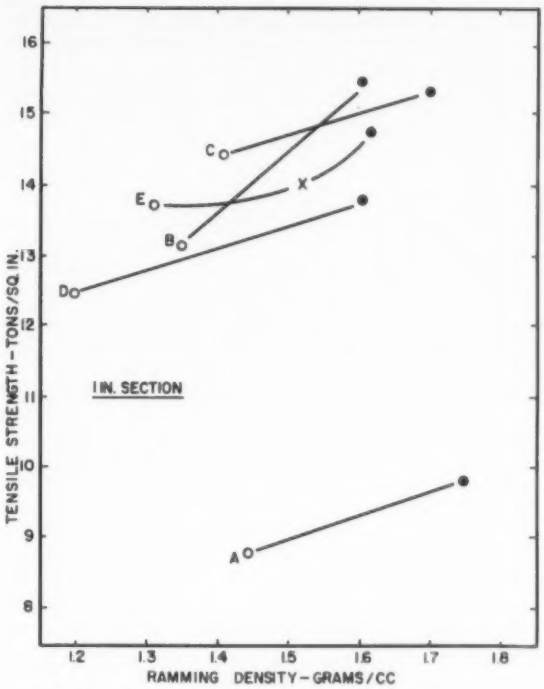


Fig. 14 — Mean tensile strength values for 1 in. diameter bars machined from step castings plotted against ramming density (see Fig. 13 for key, and Table 4 for results).

the iron of nominal C.E. 4.2, the graph shown in Fig. 7 is obtained for the 1¼-in. dia. bars. If chilling power of a mold is related to the tensile strength of a bar of a given diameter cast in that mold, it can be seen that 1) a coarse-grained silica sand has a greater chilling power than a fine-grained silica sand, 2) an increase in the ramming density increases the chilling power of both fine- and coarse-grained silica sands, and 3) the bond, with the exception of sodium silicate, has little effect upon the chilling power of silica sand aggregates.

The small effect of the bond, with the exception

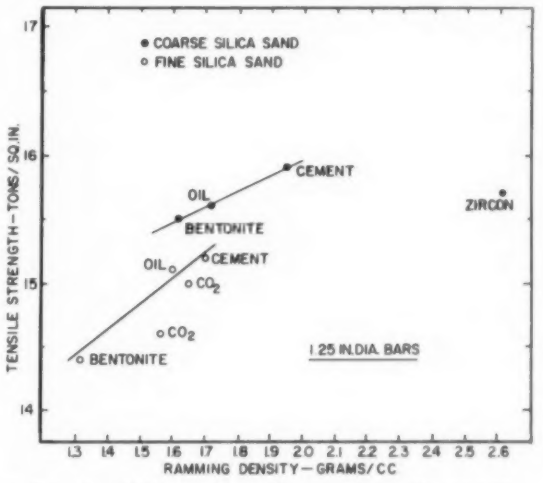


Fig. 15 — Mold variables effect on the tensile strength of 1¼-in. diameter bars of iron J (C.E. = 4.2).

of sodium silicate, upon the chilling power of silica sand molds is surprising. Pell-Walpole[8] found that replacing bentonite by linseed oil as a bond for a silica sand greatly increased the chilling power. He explained this in terms of the conductivity of the bond, the linseed oil forming a film of carbon on each sand grain during baking– this film having superior conductivity to that of the bentonite bond– thus increasing the apparent thermal conductivities.

The only bond found to have an appreciable effect upon chilling power is sodium silicate. This bond consists of a silica gel which compared with the oil bond would have a low thermal conductivity. However, it seems unlikely that this wholly explains the low results obtained, and it is perhaps possible that this bond produces materials that are opaque to heat radiation which would reduce the heat transferred by this mechanism, thus reducing the apparent thermal conductivity.

An important feature of the results is the relatively low tensile strengths of the bars cast into the shell molds. Morey et al.[9] consider that the poor chilling power of an unbacked shell mold is due to the poor heat storage capacity of the system, and show that it can be improved by using suitable backing materials. Ruddle[2] suggests that the poor chilling power may be due partly to the heat of combustion of the resin.

TABLE 7 – DETAILS OF MOLD AND MOLD MATERIAL USED IN MAKING VALVE GUIDES AND PISTON RINGS AND TENSILE AND HARDNESS RESULTS OBTAINED FROM THE CASTINGS

		Sand properties				Mold properties		Casting properties		
Casting	Sand	Green Comp., lb/in.	Green perm.	Density, g/cc	Moisture, %	Hardness	Density, g/cc	En. x 10^6 lb/sq. in.	Tensile. Tons/ sq. in.	Hardness, Brinell 5mm, 750 kg
No. 1 Valve guide	Erith	8.5	30	1.46	3.3	65	1.15		13.0	215/220
	Bromsgrove	12.5	36	1.47	3.4	75	1.49		13.63	213/219
	Hensall	13.5	105	1.47	3.8	71	1.40		10.83	210/213
	Southport	12.0	150	1.45	3.2	70	1.15		12.8	216/224
No. 2 Valve guide	Erith	8.5	30	1.46	3.3	70	1.10		13.2	197/229
	Bromsgrove	12.5	36	1.47	3.4	70	1.40		12.7	217/229
	Hensall	13.5	105	1.47	3.8	70	1.36		13.1	197/229
	Southport	12.0	150	1.45	3.2	65	1.00		13.1	207/229
No. 3 Valve seat	Erith	7.8	30	1.46	3.6	85	1.20			99/102
	Bromsgrove	12.6	40	1.46	3.5	85	1.40			100/103
	Hensall	13.5	105	1.47	3.8	84	1.27			99/103
	Southport	12.0	150	1.45	3.2	80	1.10			100/104
No. 4 Piston ring	Erith	8.5	30	1.46	3.3	78	1.00	15.6	22.4	102/104
	Bromsgrove	12.8	36	1.47	3.4	78	0.89	15.5	22.3	102/104
	Hensall	12.0	90	1.45	4.0	76	1.10	15.5	23.2	102/104
	Southport	10.0	140	1.48	3.2	74	1.02	15.4	22.3	101/103
No. 5 Valve plate	Erith	7.8	30	1.46	3.6	78	1.10		Rockwell 'B'	102/104
	Bromsgrove	12.6	40	1.47	3.5	78	0.90		Rockwell 'B'	102/104
	Hensall	12.0	90	1.45	4.0	76	1.20		Rockwell 'B'	101/103
	Southport	10.0	140	1.48	3.2	74	1.05		Rockwell 'B'	102/104

Results of second series of tests.

			Max. stress Hounsfield		
No. 1					
Repeated valve guide	Erith	1.19	10.2		170/182
	Bromsgrove	1.42	11.8		187/197
	Hensall	1.30	11.0		187/191
No. 4			En. x 10^6	Tensile	Rockwell 'B'
Repeated piston ring	Erith	1.27	14.3	21.4	98/99
		1.29	14.7	22.9	98/100
		1.31	13.9	22.1	99/100
	Bromsgrove	1.34	14.5	21.7	98/100
		1.35	14.5	21.6	99/101
		1.35	14.5	21.7	100/102
	Hensall	1.19	14.2	22.2	99/100
		1.25	14.6	23.2	98/99
		1.27	14.6	22.0	98/99
	Southport	1.28	14.4	20.8	99/101
		1.31	14.9	21.5	99/101
		1.32	14.0	20.1	100/101

Moisture Content of Molds

The moisture content of a mold, in the case of small castings and low casting temperatures, increases the cooling power of the mold.[3,6,7] Directly after pouring, the moisture adjacent to the metal/mold interface vaporizes, resulting in a large increase in the rate of heat absorption, and the subsequent movement of this steam away from the metal/mold interface results in a substantial transfer of heat outward. Ruddle and Mincher[3] consider that the effect of moisture upon the cooling capacity of mold materials decreases with increasing temperature, and has only a small effect even at copper casting temperatures.

Silicon-carbide Molds

The 1-in. dia. bars were mottled in both coarse and medium grades, and the effect of grade in silicon-carbide does not appear to have any effect on the tensile strength of the iron. However, vitrified molds gave a higher tensile strength than the baked molds, due apparently to the higher conductivity of the closer-bound vitrified mold. When silicon-carbide is used as a sand, the mechanical strength of the bars is not greater than the best mechanical strengths obtained in any other mold material used. This is in agreement with expectation, since it is not the thermal conductivity of the sand grains which exerts most influence over the cooling rate. On the other hand, when a vitrified bond is used then a much higher cooling rate is obtained and mottled bars result.

Effect of Various Mold Materials on Different Types of Cast Iron and of Inoculation

The influence of mold material and bar diameter upon the tensile strength of gray iron of various carbon equivalents is shown in Fig. 9. This indicates that tensile strength increases with decreasing carbon equivalent. All the ½-in. dia. bars cast in iron 'D', nominal C.E. 3.7, were mottled.

The results from the inoculated series are shown in Fig. 8. The base iron had the same nominal composition as iron 'J' (Fig. 9), and it can be seen that the variation in tensile strength with bar diameter is very much reduced and that the ½-in. dia. bars, which without inoculation were mottled, solidified gray. Inoculation reduced the coefficient of section sensitivity, i.e., the slope in logarithmic co-ordinates, from 0.37 to 0.17.

The effect of inoculation is greatest when the carbon equivalent value of the iron is low, as in the case of the iron under consideration, that is when the composition is such that the iron would very nearly solidify mottled and the eutectic cell size is large. In this case inoculation causes the graphite, which would be under-cooled in the absence of inoculation, to be of the flake type and the cell size to be reduced. It is therefore to be expected that the effect of inoculation would be to reduce the effect of variations of cooling rate, and therefore the variation of tensile strength with bar diameter.

Tests Using Square Bars

The first tests with square bars had shown no correlation whatever, an anomaly which was traced to be due to feeding. The round bars had a slight thickness at the end which acted as a feeder, and this had been omitted from the first series of square bars. When the square bar tests were repeated with the slight thickness on the end the results were reproducible and show a correlation similar to the round bars. The three sands had the same effect on square bars, but there was a most unusual effect in that the square bars had lower properties than the round bars.

Furthermore, the tests had been repeated in some light alloys and copper-base alloys, and in each case the properties of square bars were lower. Consideration was given to the effect of feeding as the thickness at the end of the bar is not a feeder in the true sense. Various degrees of feeding were tried as a variable, but were found to have no effect so long as the thickness at the end of the bar was not omitted.

Effect of Superheating the Metal

The degree of superheat to which cast iron is subjected is recognized as one of the factors which influence the structure and properties of gray iron castings. Within the temperature range considered, superheating increases the tensile strength of the iron used in the experiments, and the superheating temperature must be controlled.

Work Carried Out by Members

This work was carried out under practical conditions in a number of foundries operating under widely differing conditions, and the results indicated graphically in Figs. 13, 14 and 15, and in tabular form in Table 4, show that the effect of sand grain size and ramming density is maintained in all foundries.

In the case of iron 'A' where only one type of sand was used (Bromsgrove) the difference in tensile strength appears to be of almost the same magnitude as obtained in other foundries using coarse and fine sands as well as varying ramming density. To investigate this further the second program of work was carried out, and from the results shown at the bottom of Table 4 it will be noticed that the average difference in tensile strength when using one sand at extremes of moldable ramming density is about half that which could be expected when using a coarse sand rammed hard and a fine sand rammed soft.

It now appears that the difference in tensile strength obtained with iron 'A' in the first series and using only one sand is exceptional.

Work Carried Out on Piston Rings and Valve Guides

This work shows little evidence which is relevant to the other work reported. The physical results and microstructures are all within the usually expected variations, and are therefore not illustrated. It must be borne in mind, however, that the piston-ring castings are made in hypereutectic iron. Another point to emerge was that with the exceptionally great care taken to achieve uniform conditions of molding, and in the first series uniform ramming density, the En and tensile scatter was reduced to about one quarter of its usual range.

It was considered that it was unlikely that any

real effect would be observed with the small differences in density, and as the sands were all fine the differences in both grain size and mold density were such that no great difference could be expected.

CONCLUSIONS

The following main conclusions may be drawn from these investigations:

1) The work at the University and the field tests carried out in production foundries using standard materials in everyday use demonstrated that the tensile strength of an iron is influenced by the mold material, the tensile strength being higher when the mold material is coarse-grained and rammed hard and lowest when the mold material is fine-grained and rammed soft.
2) The influence the mold exerts on the tensile strength is due to the mold material or mold density or both affecting the cooling rate of the molten metal.
3) The maximum change in tensile strength brought about by the widest range in sand mold material and mold density studied is approximately 20 per cent. This is from half to one third of that which could be expected by a change in section size (bar diameter) from 1¼-in. to ½-in. diameter.
4) The results of the tests using cast test bars are confirmed by the results from test bars machined from the step castings made under commercial conditions in four foundries using iron with widely different carbon equivalent values.

ACKNOWLEDGMENTS

A scholarship in foundrywork provided by the Joint Iron Council enabled the Department of Industrial Metallurgy of Birmingham University to undertake the whole of the investigational work. To both of these bodies the sub-committee wishes to express its warmest appreciation.

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INTERRELATION BETWEEN STRESS CONCENTRATION AND CASTABILITY

By J. B. Caine

ABSTRACT

There is a close relationship between shapes designed to minimum stress concentration, maximum load carrying ability and the castability of such shapes. The designer and foundryman are in basic agreement on this subject to the point that most, if not all, shapes designed for minimum stress concentration are shaped for maximum castability.

INTRODUCTION

For years the foundryman, individually and collectively as an industry, has been trying to interest the designer and engineer in designing for castability. The results of this campaign have not nearly equalled the efforts expended upon it. Perhaps one reason is that the approach is psychologically wrong. The designer and engineer are not particularly interested in the problems of the foundryman. These individuals are interested in load-carrying ability, and should be interested in the mutual problem of load-carrying ability and castability.

The examples discussed in this paper are only a few that illustrate this mutual problem. The designer's interest in stress concentration can almost always be translated into foundry terminology by substituting "strain" for "stress". The shape that plagues the foundryman with defects due to contraction strain concentration during solidification and subsequent cooling is prone to plague the designer due to stress concentration in service.

THE PROBLEM

In an effort to illustrate this mutual problem, the writer has attempted to summarize the known information on stress concentration of a few simple shapes, and correlate this information with heat transfer data on similar shapes. Only the simplest shapes are discussed in this paper. The simpler shapes must be discussed and understood first to properly understand the stress pattern of more complicated shapes. Then too, as the shape becomes more complicated to the point of most castings, generalization based theoretical and photoelastic studies of stress concentration, thermal analysis of strain concentration, becomes less precise. Each shape, or small groups of shapes must be studied as individuals. The problem becomes one of individual stress analysis by brittle laquer, or strain gage techniques.

Specifically, this discussion compares stress analysis data, determined mostly by photoelastic methods, with thermal analyses determined by thermo-couple and electric analogue techniques. As none of the work was done with the problem under discussion in mind, there must be some extrapolation and interpretation of the original data. This extrapolation introduces errors, but at the present state of knowledge the errors should not be serious. More important is the question of limits to the conclusions.

The photoelastic data given seem reliable in that the stress concentration factors (K_t), derived from photoelastic work, check closely experimentally determined decreases in fatigue strengths of metals (K_f). The stress concentration factors (K_t) apply to all metals. A major point here is the particular metal's sensitivity to stress concentration. This is not only a function of each metal, but also of the hardness and microstructure of a particular metal.

The limits to the correlative strain concentration data must be more strongly exphasized. Practically all quoted data are specific only to steel. Most are specific only to steel cast in 4-in. sections. For all practical purposes for the present, it does not seem necessary to restrict the correlation only to steel poured in heavy sections. Thermal gradients in shapes cast of metals with temperatures and solidification characteristics other than those of steel will differ from those shown, but the relative gradients should be similar.

A similar situation exists for section sizes other than the 4-in. section that will be referred to repeatedly. Thermal gradients will vary due to section size, but again the relative gradients should be similar. Therefore, all dimensions will be given in relation to section thickness (t).

A major exception to this discussion is gray cast iron. This most castable of all metals is not prone to the defects associated with solidification shrinkage common to most other cast metals. Its different strengths in tension and compression make other shapes more attractive to the designer than those best suited for the so-called ductile metals. The shapes discussed in this report must be amended for gray iron design.

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The first shape to be considered is the simple corner. As can almost be expected, this most basic shape has been taken for granted and overlooked. There are heat transfer data on this shape, but to the writer's knowledge, no basic stress analysis data. Therefore, a discussion of this basic problem must be deferred, to a later portion of this paper.

BASIC SHAPES

The "L" Junction

The next simplest shape is the "L" junction of Fig. 1. Stress concentration studies of this shape, as influenced by the radii of the fillets, have been made by Roark, Hartenberg and Williams.[1] The K_t values reported in reference (1) have been plotted in Fig. 1. Before delving more deeply into this subject, perhaps an explanation of the significance of the K_t (stress concentration) factors is in order.

The value K_t denotes the increase in overall stress due to geometry. The geometry is established basically by design, but may be modified or accentuated by other factors, macro or micro discontinuities caused by fabrication or inherent in the metal, type of load application, accidental overloads and misalignment. For example, a K_t factor of 2.0, in Fig. 1 and those to follow, indicates that for every 1000 lb of overall load, the metal at the surfaces of the junctions of sections (usually the fillets) is subjected to twice the overall stress, or to a stress of 2000 lb. A stress concentration factor of unity (1.0) denotes no stress concentration, and the load is distributed evenly throughout the shape.

These values, 1.0, 1.3, 1.7, 3.0 seem rather innocuous, but they are not. A K_t factor of 3.0 means that the load in pounds, or in psi in certain areas is tripled; K_t of 1.5 means a 50 per cent increase in load. The importance of these factors is accented when they are compared with possible changes in the metal's ability to withstand the load, tensile, yield and fatigue strength.

Consider Fig. 1 as the first specific example. It shows – as the radius of the fillet is increased from $r/t = 0.2$ to $r/t = 1.0$, K_t in tension decreases from 2.03 to 1.20. This means that the load carrying ability under these conditions of shape and loading is increased 70 per cent regardless of the type of metal. It should be emphasized that a r/t ratio of 0.2 is about equivalent to the normal 1/4-in. radius with a 1-in. section.

Castability follows, as shown by the scale drawings of Fig. 1. Brandt, Bishop and Pellini[2] have studied the thermal gradients of "L" junctions and found a freezing pattern (simplified), as shown in Fig. 1. The shaded areas of Fig. 1 represent metal containing liquid when the connecting members are completely solid. These sketches have been constructed from the 50-sec isochromes of Brandt, Bishop and Pellini's work.[2]

It must be re-emphasized that the isochromes are specific only for steel cast in 4-in. sections. The data should be qualitatively relative for other metals, cast in other sections. Another qualification must be made. Brandt, Bishop and Pellini did not investigate the specific problem of size of fillet on the freezing pattern. It is assumed constant in regard to fillet radii. This assumption should not introduce a great error, and if anything should make Fig. 2 conservative, for the larger radii should cause thicker casting skins at the fillet.

With radii under $r/t = 0.5$ in Fig. 1 there is liquid metal at the sand-metal interface of the fillet when the connecting members are completely solid. The probability of shrinkage defects at the surface of the highly stressed fillet is self evident. With radii over 0.5 r/t, and especially when the ratio approaches $r/t = 1.0$, there is appreciable solid metal at the fillets, and the thermal isochromes follow the geometric outlines of this junction of sections.

The dotted lines of the sketches of Fig. 1 denote the 10-sec isochrome for the 4-in. section. Metal between the dotted lines and the sharp outer corner is cooling and freezing over five times as fast as the metal in the hot spot. The chances for trouble due to steep temperature gardients is self evident. Cooling cracks in hardenable alloys and chilled edges in iron are just two possible defects that are caused by these steep temperature gradients. The analogous stress concentration picture does not show up with the tensile loading of Fig. 1, for the sharp outer corner is in compression.

Lyse and Johnson[3] have partially investigated stress concentration in the same "L" junction, but stressed in torsion. Their results are plotted in Fig. 2, in comparison with those of Fig. 1 in tension. There is a significant increase in stress concentration when this shape is stressed in torsion. A prime suspect is the sharp outer corner that is now stressed in torsion and not in compression. It can at least be inferred that if the outer corner be rounded as shown in Fig. 2b to a 2t radius, stress concentration in torsion would approach that in tension and perhaps both would be decreased. At the same time, rounding the outer

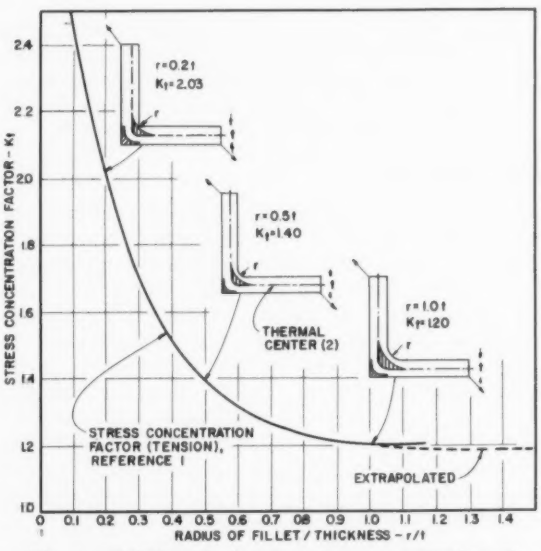

Fig. 1 — Relationship between stress concentration of an "L" section in tension and thermal gradients near the end of solidification.

corner removes the temperature gradient that causes cooling rates to vary within a fraction of an inch by a factor over five. Need it be said that such streamlining is easily accomplished by casting, is difficult or impossible by any other forming method?

Figures 1 and 2 illustrate the writer's thesis, the common problem of stress concentration and castability. A rather simple change from Fig. 2a to Fig. 2b has increased the load carrying ability of the common "L" junction, at least in fatigue, by 70 per cent, an appreciable increase. The same change has increased castability by moving the thermal center to the geometric center, and has eliminated extreme temperature gradients. It is no longer necessary to sell castability. If streamlining is done properly castability takes care of itself.

Another qualification must be made. A thermal analysis of the 1t-2t rounded corner has not been made. However, it can be safely assumed that the outer edge of the hot spot of Fig. 2b does not extend beyond the geometric centerline. The surface area-volume ratio of the outer surface of the 2t radius is greater than the straight sides of the legs. Therefore, the cooling rate at the geometric center of the corner must be greater than in the straight legs. There is no reason to believe that the heat flow across the 1t inner radius of Fig. 2b is less than across the same radius of Fig. 2a. Therefore, the size of the hot spot in Fig. 2b must be materially decreased. However, this reasoning must be checked before being accepted without question.

For example, the "L" junction of Fig. 2a is quite resistant to hot tearing even though it is prone to shrinkage defects in the fillet. The reason is that the sharp corner is cooling so fast that it holds the junction together, possibly to the point of subjecting the fillet to compression. Removing this temperature gradient can conceivably cause trouble. Perhaps a compromise between Figs. 2a and 2b is necessary. Only experimental work will settle this point.

The "T" Junction

Figure 3 compares stress concentration and castability as measured by heat transfer for the next more complicated junction, the "T" junction. Stress concentration values in relation to fillet radii are quite similar to those of the "L" junction. They also level off at fillet radii of about 1.0t, and there is little to be gained with larger radii as far as stress concentration is concerned.

Just a casual inspection of the thermal gradients as determined by Brandt, Bishop and Pellini[2] shows why such junctions are so prone to hot tearing. There is a path of liquid metal extending through the junction of the horizontal arm of Fig. 3a when the uniform arms are completely solid. Contraction strain is not only concentrated at this junction, but also the partially liquid metal can offer no resistance to this strain. Increasing the radius as in Figs. 3b and 3c gives a solid envelope around the hot spot as well as decreasing stress concentration in service. It is evident that a combination of a sharp corner as in Fig. 3a, plus a hot tear or shrink crack, can increase stress concentration to values approaching five.

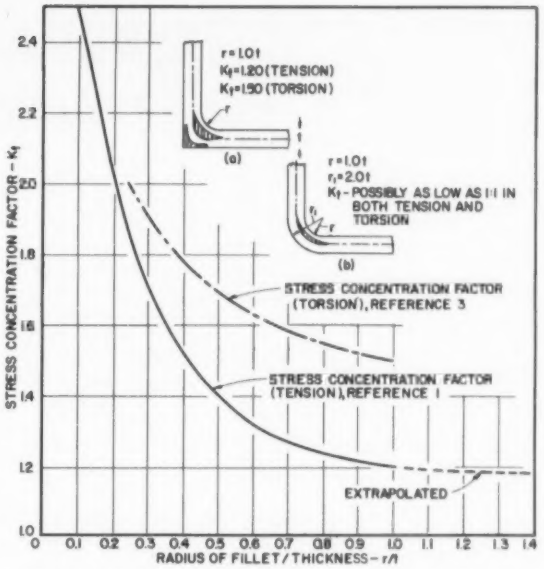

Fig. 2 — Relationship between stress concentration in tension and torsion and thermal gradients during solidification.

The larger radii of Fig. 3c will not guarantee freedom from hot tears. They can only be expected to reduce their severity. So much is dependent on so many other factors, particularly size, that further discussion in a paper of this type is of no value. If "T" junctions must be used in shapes that show shrinkage defects the foundry must carry on from the point of 1t radii with chills, brackets, collapsible molding and core sands.

An interesting point of conjecture is shown by Fig. 3d. Several publications on casting design recommend "dimpling" a "T" section to obtain uniform geometric sections. When this is done, as in Fig. 3d, it is possible that the "dimple" will protrude into the hot spot and make matters worse. There

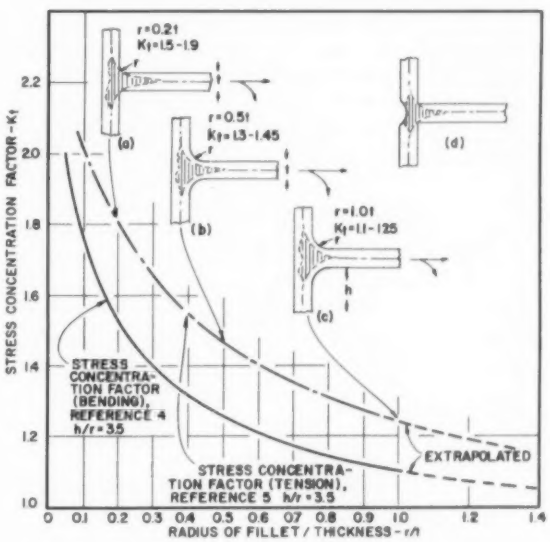

Fig. 3— Relationship between stress concentration and thermal gradients of "T" junctions.

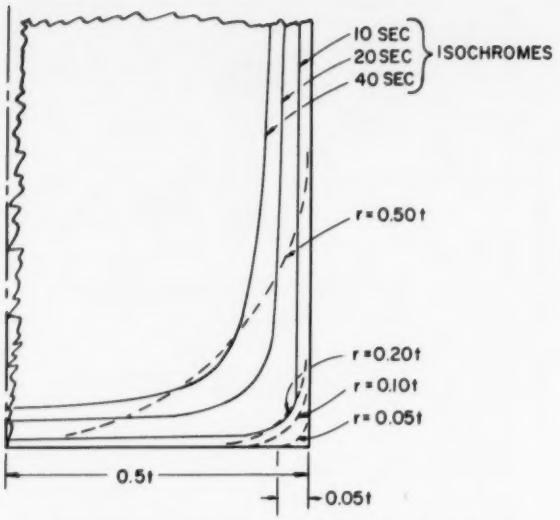

Fig. 4 — Relationship between thermal gradients and corner radii.[6]

may now be three rather than one semi-liquid cross-sections. Unfortunately, the literature on casting design is full of recommendations such as this, not based on factual evidence but on an idea. Most suggestions are good, but there are too many that possibly, or probably, are not.

It is possible for the reader to extrapolate the data for "T" sections to the more complicated "K" and "X" sections. No stress or heat transfer data are available for these more complicated junctions and they can not be discussed in detail. However, it does not seem to be too much in error to recommend the 1t radius for all cast junctions of sections as a minimum. "K" and "X" junctions should be simplified to staggered "T" junctions wherever possible, as has been recommended in practically all publications on casting design.

The Simple Corner

With the preceding in mind, it is perhaps possible to return to the most basic problem, that of the simple corner. The solid lines of Fig. 4 denote the thermal isochromes of the corner of a finite cylinder at 10, 20 and 40 sec, as determined by Paschkis.[6] The dotted arcs show the outlines of various corner radii. A radius of 0.10t removes the metal that cools at rates faster than the metal of the surfaces making up the corner. As the 0.10t radius increases the surface area-volume ratio of the corner, it is probable that this value is a minimum, and that corner radii between 0.10 and 0.20t are necessary to remove the highly cooled metal.

When hardenable metals are cooled, the elimination of these high temperature gradients will do more than any other single step to eliminate corner cracks. This is true for any hardenable metal, regardless of the forming method. In any other forming process than casting, rounded corners usually require an additional chamfering operation. Most rounded cast corners can be made on the pattern with a simple templet and a piece of sandpaper. The two exceptions, sharp corners formed at partings and where cores leave the casting cavity can be remedied by simple pattern construction if they are specified before the pattern is made.

Rounding external corners to 0.20t radius seems even more important when casting gray iron. Here, the problem is not only corner cracks, but also chilled edges. Chilled edges many times limit the strength of iron castings in that without expensive alloying, or heat treatment, a particular casting cannot be machined if cast with an iron with any higher strength. Would not the elimination of the corners simplify the problem?

No correlative data are available on service stress concentration of simple corners. However, the correlation between thermal and stress concentration data seems so close that it does not seem too hazardous to assume the same decrease in stress concentration as is obtained in thermal gradients.

SUMMARY

Three general rules can be advanced from the preceeding correlations between stress and strain concentration. All dimensions can be expressed as fractions of the section thickness, t.

1) Corners should be rounded to 0.1 to 0.2t radius.
2) Fillet radii of 1.0t seem generally applicable to most junctions of sections.
3) Outer radii of 2t when used in conjunction with 1t fillet radii seem the best compromise between stress concentration, castability and moment of inertia of "L" and "K" junctions.

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EXPERIMENTAL DETERMINATION OF SPECIFIC SURFACE AND GRAIN SHAPE OF FOUNDRY SANDS

By Franz Hofmann

ABSTRACT

The methods for determining the grain shape of foundry sands described in the literature are based almost exclusively on microscopical observation. They are subject to the disadvantage of being rather inaccurate and to personal interpretation. With the new testing method described the average grain shape of sand grain distributions as well as of individual grain size fractions can be determined experimentally and reproducibly.

TESTING PRINCIPLE

With the permeability method described herein it is possible to determine the actual specific surface of sand and other granular material, i.e., the surface in sq cm of all sand grains contained in one gram of sand. On the other hand, the theoretical specific surface of the sand may be calculated from its sieve analysis assuming that all grains are spherical. The value of the theoretical specific surface is always smaller than that of the actual specific surface, due to the shape of the grains which are not spherical, and which for this reason have a larger surface area with identical weight.

The more angular the sand grains are, the larger the difference is between actual and measured specific surface area and theoretical specific surface area. Dividing the value of the actual specific surface area of sand by the value of the theoretical specific surface area yields a coefficient for the angularity of a grain. This is a unit for the average grain shape:

$$E = \frac{S_w}{S_{th}}$$

where E = Coefficient of angularity.
S_w = Actual measured specific surface in sq cm/g.
S_{th} = Theoretical specific surface assuming that all grains are of spherical shape, in sq cm/g.

Only in the ideal case of a sand consisting entirely of spherical grains S_w would be equal to S_{th} and E would be 1.

This principle has been applied by Robertson and Emödi[1] for the first time to characterize the rugosity of granular solids, and the method has been adapted to test foundry sands by Davies and Rees.[2,3]

DETERMINATION OF THE ACTUAL SPECIFIC SURFACE

The measurement of the actual specific surface of sand bases on the flow of air through a long cylindrical sand bed. The actual specific surface S_w is a function of porosity and permeability of this bed.

$$S_w = \frac{\text{Constant}}{\text{Bulk Density}} \sqrt{\frac{\text{Porosity}^3}{\text{Permeability}}}$$

Basing on a formula of Kozeny[4], Carman[5] has suggested the following, semi-empirical formula:

$$S_w = \frac{1}{\delta(1-\epsilon)} \sqrt{\frac{\epsilon^3 A p g}{K \eta Q L}}$$

where

δ = specific weight of material investigated (silica sand 2.65).
ϵ = porosity of the sand bed (pore space volume per volume unit of the sand bed).
A = cross-sectional area of the sand bed (sq cm).
p = pressure difference between the ends of the sand bed (dyn/sq cm).
g = gravitational acceleration (981 cm/sec^2).
K = constant (= 5, not affected by apparatus and grain size).
η = dynamic viscosity of air (g/cm/s).
Q = rate of flow of air through sand bed (cc/sec).
L = length of sand bed (cm).

g and K are constants so that the equation may be simplified as follows:

$$S_w = \frac{14}{\delta(1-\epsilon)} \sqrt{\frac{\epsilon^3 A p}{\eta Q L}} \qquad (1)$$

This equation contains the permeability formula of Darcy:

$$Q = PE \frac{A p}{\eta L} \quad \text{or}$$

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$$\text{Permeability} = PE = \frac{Q\,\eta\,L}{A\,p}$$

This permeability formula shows the same relation as the gas permeability formula for foundry sands, but it also considers the viscosity of air. The value of the dynamic viscosity of air (η) is considered to be constant at room temperature and is equal to $181 \cdot 10^6$.

Davies and Rees[2,3] have applied the measuring principle of Lea and Nurse[6] for foundry sands. The method was first developed for measuring the specific surface of fine powders, basing on Carman's equation. Air is passed by water pressure through the sand arranged as a cylindrical bed in a 50 cc glass burette, and then through a fine orifice (actually a capillary tube). Pressure is measured before and after the sand bed.

Rigden[7] simplified the principle of Lea and Nurse by using a U-tube, and drawing air through the powder sample by means of the liquid column in a U-tube, first lifted by suction to a certain height. Blaine[8] further developed the U-tube measuring principle. He simplified the testing device to its present state as it is used for evaluating the specific surface of fine powders, particularly of cements. It has never been applied for granular material.

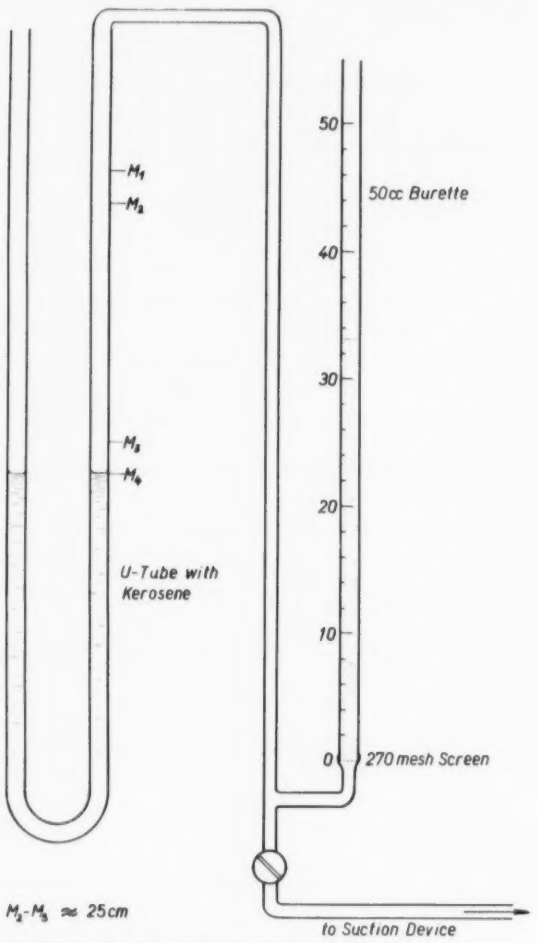

Figure — Schematical sketch of the equipment for the determination of the actual specific surface of sands.

The measuring method shown in the figure has been developed by the author and bases essentially on the principle of Blaine, adapted to permit the measurement of the specific surface of granular materials, mainly sands.

Air is drawn through the sand bed in a measuring pipette by means of the liquid column in the U-tube, which has been lifted by suction up to mark M_1. It is now allowed to drop, drawing air through the sand bed. The time used by the liquid column to drop from mark M_2 to mark M_3 is measured. Equation (1) may now be adapted as follows to this measuring method:

The value Q, i.e., the (average) amount of air drawn through the sand bed per time unit is

$$Q = \frac{V}{T}$$

where V = total volume of air (ccs) flowing through the specimen equalling the volume of the length of U-tube between marks M_2 and M_3.

T = time required by the liquid column for dropping from M_2 to M_3 (sec).

Using equation (1), the specific surface will then be

$$S_w = \frac{14}{\delta(1-\epsilon)} \sqrt{\frac{\epsilon^3\,A\,p\,T}{V\,\eta\,L}} \qquad (2)$$

According to Rigden[7] and Blaine[8] the pressure (p) may be expressed as follows for the U-tube method:

$$p = \frac{0.8686\ h_1\ \gamma}{\log\ (1+2\ h_1/h_2)}$$

where

h_1 = height between M_2 and M_3 = measuring interval.

h_2 = double height between M_3 and M_4.

M_4 = equilibrium height of the liquid column.

γ = specific weight of the liquid in the U-tube (kerosene or any suitable mineral oil of low viscosity).

With equation (2):

$$S_w = \frac{14}{\delta(1-\epsilon)} \sqrt{\frac{\epsilon^3\ A \cdot 0.8686\ h_1\ \gamma}{V\ L \log\ (1+2\ h_1/h_2)\ \eta}} \sqrt{T}$$

or with $\delta(1-\epsilon) = D$ = bulk density of the sand bed, the formula may be expressed as follows:

$$S_w = \underbrace{\frac{1}{D}\sqrt{\frac{\epsilon^3}{L}}}_{X} \cdot \underbrace{14\sqrt{\frac{A \cdot 0.8686\ h_1\gamma}{V \log\ (1+2\ h_1/h_2)\eta}}}_{Y} \cdot \underbrace{\sqrt{T}}_{Z}$$

or

$$S_w = X \cdot Y \cdot Z \qquad (3)$$

The value for X results from the volume and the length of the sand bed (of known weight) yielding also D and ϵ.

The value for Y is a constant of a particular apparatus, and will have to be determined only once. The measurement is therefore greatly simplified, and is reduced to the determination of the volume of the sand bed, its length for a particular apparatus, and the time measurement for the drop of the liquid column between M_2 and M_3, respectively. Basing on these figures and the specific weight of the material being tested, the actual specific surface is easily obtained.

As a preliminary to testing, the sand is boiled with an addition of sodium-pyrophosphate, and subsequently stirred up in the same manner as used for the determination of the clay content. It is then washed through a 270 mesh screen by a gentle stream of water, and then dried. The initial sample of the sand must be big enough to produce a sample of exactly 50 grams of washed and dried sand. The same sample is subsequently used for the determination of the theoretical specific surface by means of the sieve analysis.

The dry sand is filled as uniformly as possible into the 50 cc burette which stands upside-down, and is closed by a 270-mesh screen at the zero mark. The burette is slightly tapped by hand or with a pencil until the sand volume cannot be reduced any further. From the volume results the length of the sand bed.

Various sands have different bed volumes. The finer the sand, the larger the bed volume. At the same time, the grain size distribution has an effect; a narrow distribution giving higher volumes than a wide distribution. Together with the gaging of the apparatus, it is possible to draw curves for various bed volumes and flow times T. Using these curves, the determination of actual specific surface is simple and fast.

DETERMINATION OF THEORETICAL SPECIFIC SURFACES

Assuming that all grains are spherical, the theoretical specific surface S_{thi} for a particular grain size fraction (sieve interval), i is

$$S_{thi} = a_i \pi d_i^2$$

where

a_i = the number of sand grains of the particular screen interval (i.e., of the particular grain size fraction).

d_i = the average diameter of the grains equaling the average diameter of the particular screen interval opening (medium grain size diameter of the grain size fraction) in cm.

The total theoretical specific surface is

$$S_{th} = \Sigma a_i \pi d_i^2 \qquad (4)$$

The number a_i of grains per fraction is not known, however the weight P_i of a particular sieve size fraction (grams):

$$P_i = a_i \frac{1}{6} \pi d_i^3 \delta$$

where δ is the specific weight of the grains, i.e., 2.65 for silica.

Hence

$$a_i = \frac{6 P_i}{\pi d_i^3 \delta}$$

and with equation (4)

$$S_{th} = \Sigma \frac{6 P_i}{d_i \delta}$$

or per gram of sand:

$$S_{th} = 2.26 \frac{\Sigma \frac{P_i}{d_i}}{P} \qquad (5)$$

where P = the total weight of the sand sample (usually 50 grams).

For determining the theoretical specific surface quickly, the factors for the standard grain size fractions (sieve intervals) for foundry sands listed in Table 1 may be used.

The factors are the average specific surface of 1 gram of sand for each particular sieve interval, assuming that the grains are spheres.

For determining the theoretical specific surface of a particular sand, the sand weight on each screen is multiplied by the pertinent factor. The products of the multiplications of all intervals are added to give the total product, which is then divided by the total weight of the sample (50 grams). It is also possible to multiply the percentage values of each particular fraction by the respective factor and to divide the total product by 100.

Example

a) Actual Specific Surface

Sample weight = 50 grams.

Volume of sand bed = 31 cc.

$$\text{Bulk density } D = \frac{\text{sample weight}}{\text{sand bed volume}} = \frac{50}{31} = 1.61 \text{ grams/cc.}$$

$$\text{Porosity} = \epsilon = \frac{\gamma - D}{\gamma} = \frac{2.65 - 1.61}{2.65} = 0.39$$

Flow time T for a particular apparatus used = 28 sec.

From the above figures, X can be calculated, whereas the figure for L is obtained for the appar-

TABLE 1 – FACTORS FOR STANDARD GRAIN SIZE FRACTIONS

Screen Interval (U.S. Series Equivalent Number)	Factor
12	9.8
20	18.2
30	31.8
40	45.1
50	63.7
70	89.9
100	127.3
140	180.1
200	254.0
270	355.9
Pan	619.2

atus in question by multiplying the volume of the sand bed by 0.8767.

Log *Y* is a constant for the apparatus in question and is 2.998. *Z* results from *T* determined by means of a stop watch.

From the graphical data for a particular apparatus, the specific surface value may be read directly for the sand bed volume for 50 grams and the flow time.

In the case mentioned above, the actual specific surface is

$$S_w = 154 \text{ cm}^2/\text{g}$$

b) Theoretical Specific Surface

Sieve Interval (U.S. Series Equivalent Number)	Weight retained on screen, grams	Factor	Product
30	0.38	31.8	12.1
40	9.35	45.1	421.7
50	17.16	63.7	1093.1
70	14.30	89.9	1285.5
100	2.78	127.3	353.9
140	2.46	180.1	443.0
200	1.67	254.0	424.2
270	1.86	355.9	661.9
Pan	0.23	619.2	142.4
Total	50.00		4837.8

$$S_{th} = 4837.8 : 50 = 96.8 \text{ cm}^2/\text{g}$$

c) Coefficient of Angularity (E) (Table 2)

$$E = \frac{S_w}{S_{th}} = \frac{154}{96.8} = 1.59$$

POSSIBILITIES OF APPLICATION OF SPECIFIC SURFACE EQUIPMENT

The determination of specific surface alone can be of interest for the preparation of core sands. Pure silica sands require more binder with increasing fineness. The quantity of binder required d. :ls on the specific surface. It must be noted, howe. "at the relationship exists only for pure silica sand where each grain is a single, rolled, compact crystal of quartz. There are, however, certain silica sands containing a large quantity of porous grains which require more binder than the specific surface would indicate.

In this case, the determination of specific surface, and comparison with pure and compact silica sands with identical specific surface, permits the determination of the requirements for additional binder, due to porosity of the grains and which does not act as a binder.

TABLE 2 – EXAMPLES OF ANGULARITIES OF SOME SILICA SANDS

Calibrated Glass Spheres (for comparison)	1.04
F – Ottawa Silica Sand, very well rounded	1.12
F – Lake Sand, Lake Michigan, well rounded	1.18
F – Belgian Silica Sand, subangular	1.30
F – Swiss Silica Sand, subangular	1.31
F – Swiss Silica Sand, angular	1.53
Crushed Quartz Rock, classified, 50 AFS fineness	1.58
Swiss Alpine River Sand, very angular	1.62

F = commercial foundry silica sands

The determination of the coefficient of angularity, that is of the grain shape, may be useful for the investigations of new sand deposits, or of new sands offered commercially.

Of particular interest is the combination of different testing methods with specific surface and grain shape determination, such as grain shape vs. flowability, rammability, strength, permeability, density and baked strength of core sands.

The described method of specific surface and grain shape determination can also be applied for purposes outside of foundry sand control, such as geology, sedimentary petrography, petroleum exploration, ceramics, etc.

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T&RI Trustees Urge Building of Center

■ Construction and completion of the proposed AFS Training & Research Institute Foundry Training Center building at the earliest possible date has been unanimously recommended to the AFS Board of Directors by the T&RI Trustees.

Since it will take at least two years to complete the project and the industry's need for the building will be even greater than at present, the Trustees urged the Board of Directors to proceed immediately with construction plans at the Feb. 10-11, meeting in Chicago.

An estimated timetable shows that, should the Board of Directors approve design and plans at the February meeting, building construction cannot start until April, 1960. Completion of the building is estimated at Oct., 1961 with the first T&RI classes starting one month later.

Prior to the recommendation, T&RI Institute Chairman Hyman Bornstein reviewed development of the plan to construct the building at the present site in Des Plaines, Ill.

Originally the Trustees requested deferral of construction plans in order to evaluate actual need for the proposed building, and recommended to the Board of Directors in February, 1957 that the building plans be prepared.

The Board authorized development of architectural plans and estimates with actual construction to be delayed in view of existing business conditions.

The proposed Training Center is designed to fill the industry-wide gap between graduates of high schools and vocational schools and those entering the foundry field from colleges and universities. The center will be used for up-grading and intensive training of line and middle supervisors.

It is planned that short, intensive courses will be given so that operating personnel can quickly return to duties at their plants. Courses may cover one or more concentrated subjects which can be expanded as the demands of of industry appear.

Facilities for the building are expected to include the following laboratories: foundry, metallurgical, chemical, spectrographic, physical testing and x-ray. Other rooms include: patternshop, classrooms, lunchroom and lounge, administration offices and showers and lockers.

Tips on Cutting Costs in Foundry

■ New industrial engineering techniques for foundry use were studied at the five-day course presented at Marquette University Management Center, Milwaukee.

The advanced industrial engineering course was sponsored by the AFS Training & Research Institute and operated by the University Management Center.

Subjects covered included work sampling, more accurate rating of time studies, statistical quality control and use of motion pictures.

Instructors were:

Prof. W. J. Richardson, Lehigh University, Bethlehem, Pa.

Dr. M. E. Mundel, time study authority, Milwaukee.

James Barrabee, International Harvester Co., Milwaukee.

Irving Schoeninger, Globe Union Co., Milwaukee.

Arnold Jakel, quality control consultant.

Lacey Randolph, American Steel Foundries, Granite City, Ill.

New F.E.F. Trustee

AFS National Director **Webb L. Kammerer,** Midvale Mining & Mfg. Co., St. Louis, has been appointed as the 1959—1961 AFS representative on the Foundry Educational Foundation Board of trustees. AFS is also represented on the F.E.F. board by AFS National Director **W. D. Dunn,** Oberdorfer Foundries, Inc., Syracuse, N.Y.

AFS 1896

news and views

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Honor Nine for Outstanding Work in Industry, Society

H. W. LOWNIE, JR.
Whiting Gold Medal

J. A. RASSENFOSS
Simpson Gold Medal

FRED J. WALLS
Penton Gold Medal

ROBERT H. MOONEY
Scientific Merit

HOWARD H. WILDER
Scientific Merit

ELMER C. ZIRZOW
Scientific Merit

JAMES R. ALLAN
Service Citation

B. D. CLAFFEY
Service Citation

ROY W. SCHROEDER
Service Citation

■ Nine outstanding foundrymen have been named as recipients of the Society's highest honors for merit and service. Three will be granted Gold Medals, three will receive Awards of Scientific Merit and three will be awarded Service Citations at the AFS Convention in April.

The nine were selected by the AFS Board of Awards and approved by the AFS Board of Directors.

AFS Gold Medals, originated in 1924, are awarded primarily for outstanding accomplishments of a technical nature and especially for effort over a period of time.

Gold Medal Winners

Harold W. Lownie, Jr., Battelle Memorial Institute, Columbus, Ohio. The JOHN H. WHITING GOLD MEDAL . . . . "For outstanding contributions to the Society and to metallurgical progress, especially in the field of gray cast iron."

John A. Rassenfoss, American Steel Foundries, East Chicago, Ind., the PETER L. SIMPSON GOLD MEDAL . . . . "For exceptional contributions to the Society and the steel castings industry, by elevating technical endeavor in steel foundry research."

Fred J. Walls (retired), Detroit, the JOHN A. PENTON GOLD MEDAL . . . . "For outstanding contributions to the Society and the castings industry, especially in the field of gray-iron metallurgy and foundry practice, and for life-time devotion to the industry's potentialities."

Awards of Scientific Merit

Awards of Scientific Merit, first given in 1957, are intended as a technical citation such as recognition for outstanding papers, meritorius technical services or effort and development or a process, method or engineering advancement having future possibilities.

Robert H. Mooney, Central Foundry Division, General Motors Corp., Saginaw, Mich., . . . "For technological contributions to production and working conditions in the malleable foundry industry."

Howard H. Wilder, Vanadium Corp. of America, Chicago, . . . "For noteworthy contributions to the Society and its membership in furthering the technology of ferrous castings and their acceptance."

Elmer C. Zirzow, Werner G. Smith, Inc., Cleveland, . . . "For long and conscientious effort on behalf of the Society's Sand Division in the development and application of sand technology."

Service Citations

Service Citations, also first awarded in 1957, are given to recognize members who give exceptional service to the Society, especially non-technical aspects of AFS activity.

James R. Allan, Allan Industries, Melbourne, Fla., . . . "For unswerving devotion to making the foundry a better and safer place to work, and for his leadership in developing practical engineering standards for the improvement of foundry working conditions."

Bernard D. Claffey, G.H.R. Foundry Div., Dayton Malleable Iron Co., Dayton, Ohio, . . . "For outstanding service to the Society and the castings industry in the work of its chapters, technical committees and educations development."

Roy W. Schroeder, Professor, University of Illinois, Chicago, . . . "For long and devoted service to the Society's activities in apprentice training and foundry instruction, and for his unceasing guidance of young men toward foundry careers."

Education Division Studies New Movie

■ Reactions of three different audiences to the film *Education and Our Industry's Survival* has been studied by a four-man committee of the Education Division to consider changes or the development of a second film to show development of personnel changes within the castings industry.

The film was discussed at the division meeting regarding objectives, audiences, title changes and possible changes in content.

Committee members are Chairman I. H. Dennen, Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago; A. C. Smith, American Steel Foundries, Chicago; R. A. Oster, Beloit Vocational & Adult School, Beloit, Wis.; R. W. Schroeder, University of Illinois, Navy Pier, Chicago.

Western Michigan Holds Workshop

■ Lectures and demonstrations were used to present basic foundry technology to Michigan secondary school foundry and patternmaking instructors when Western Michigan University, Kalamazoo, Mich., was host to its second all-day industrial arts workshop held Nov. 15.

John Bendix, Western Michigan University, served as chairman of the foundry section. Assisting were Dr. Charles Risher, Western Michigan University and AFS Education Director R. E. Betterley.

Workshops consisted of demonstrations on mold ramming, pouring, construction of gas-melting furnace and CO_2 coremaking. Students rammed and poured molds with each student finishing and cleaning one casting.

Molding and pouring demonstrations were conducted by Bendix and Betterley. Lectures included an explanation of the University's foundry program and a summary by Betterley of AFS educational activities. Those attending were given plans and drawings, general foundry reference material and AFS literature.

John L. Bendix

AFS Foundry Conferences

■ Four AFS regional foundry conferences will be held in February and March.

Feb. 12-13—**Wisconsin Regional,** Schroeder Hotel, Milwaukee.

Feb. 26-27—**Southeastern Regional,** Hotel Tutwiler, Birmingham, Ala.

March 13-14—**California Regional,** Huntington Hotel, Pasadena, Calif.

March 19-20—**Texas Regional,** Menger Hotel, San Antonio, Texas.

Nominate Officers, Directors for Election at Convention

■ Charles E. Nelson, Dow Chemical Co., Midland, Mich., has been nominated for the presidency of AFS for the year 1959-60. Now Vice-President, he was named to succeed the present President, L. H. Durdin, Dixie Bronze Co., Birmingham, Ala., by the Nominating Committee at a meeting held Dec. 8 in Chicago.

Norman J. Dunbeck, Industrial Minerals Div., International Minerals & Chemical Corp., Skokie, Ill., was named to succeed Nelson for the 1959-60 season.

The following were nominated to serve three-year terms as Directors of the Society.

■ **Norman N. Amrhein,** Federal Malleable Co., West Allis, Wis., representing Malleable. (Region V, Chapter Group L, Wisconsin Chapter).

■ **Cecil N. King,** Chrysler Corp., Detroit, representing Steel, Gray Iron, Brass & Bronze, Light Metals. (Region IV, Chapter Group H, Detroit Chapter).

■ **Robert E. Mittlestead,** Lectromelt Casting Div., Akron Standard Mold Co., Barberton, Ohio, representing Steel Aluminum. (Region III, Chapter Group G, Canton District Chapter).

■ **A. J. Moore,** Canadian Bronze, Ltd., Montreal, Que., representing Brass & Bronze. (Region II, Chapter Group D, Eastern Canada Chapter).

■ **W. H. Oliver,** American Radiator & Standard Sanitary Corp., Buffalo, N. Y., representing Gray Iron. (Region II, Chapter Group E, Western New York Chapter).

■ **James N. Wessel,** Puget Sound Naval Shipyard, Bremerton, Wash., representing Gray Iron, Steel, Brass & Bronze. (Region VII, Chapter Group R, Washington Chapter).

New Officers and Directors of the Society will be elected at the Annual Business Meeting in Chicago, April 15 and will take office following the close of the 1959 Annual Castings Congress and Engineered Castings Show, April 13-17.

At any time up to 45 days prior to date of the Annual Business meeting, additional nominations may be made by written petition signed by 200 members in good standing and filed with the AFS Secretary at the Central Office, Des Plaines, Ill.

CHARLES E. NELSON
President

N. J. DUNBECK
Vice-President

N. N. AMRHEIN
Director

CECIL N. KING
Director

A. J. MOORE
Director

Wm. H. OLIVER
Director

JAMES N. WESSEL
Director

R. E. MITTELSTEAD
Director

national news

Foundrymen of World to Meet in Spain for 26th International

■ Historically-rich Spain, said to have the best winter climate on the Continent, is expected to attract a large American delegation to the 26th International Foundry Congress. The Congress, sponsored by the International Committee of Foundry Technical Associations, will be held Oct. 4-10 in Madrid.

The Spanish Institute of Iron and Steel will act as host to the Congress and its president will be President of the Congress. International President Dr. Aldo Dacco of Italy will preside at the meetings of the International Committee of Foundry Technical Associations.

Final details have not been completed for the Congress program. Agustin Plana, Director of the Spanish Institute of Iron and Steel, has announced that the program will include inauguration of new institute facilities in University City. Other events will be technical conferences, meetings of the International committees, official receptions, plant visitations, tourist excursions and post-Congress tours.

Tourist attractions in Madrid include—Monuments: Arch of Triumph, Gate of Alcala, Cibeles, Neptune; historic buildings and churches—Royal Place, Cathedral, Church of San Francisco the Great; museums—the Prado, the museum of Lazaro Galdeano, Place of Libraries and Museums; great avenues—Gran Via, Pasea del Prado and Paseo de la Castellana, Oriente Square; gardens—Casa de Campo, Retiro, Parque de Oeste; modern buildings—Edificio Espana, Torre de Madrid, Telefonica, University City.

Plant visitations in the Madrid area will include both ferrous and nonferrous operations. Among the most outstanding are Construciones Aeronauticas, S.A.; Electrometalurgica del Cerro de la Plata S.A.; Forjas de Alcala S.A.; Fundiciones Inglesias, S.A.; Construcciones Jareno; Manufacturas Metalicas Mardilenas, S.A.; Fundiciones San Jose.

As host to the International, the Spanish Institute of Iron and Steel will sponsor two post-Congress tours and a special ladies program.

The first tour will be through northern Spain in which the most important heavy industry is located. The second tour will be in the south including Levante and terminating in Barcelona, an industrial region with some important foundries.

Plaza de la Cibeles, one of the most famous landmarks in Madrid. Buildings include the General Post Office, Ministry of War and Bank of Spain.

AFS Tours

Tours designed especially for Americans are being arranged by the American Foundrymen's Society. Similar tours were arranged by AFS for the International Foundry Congress held in 1953 in Paris. Any U. S. foundryman interested in participating in the tour should contact AFS General Manager Wm. W. Maloney, AFS Central Office, Golf and Wolf Roads, Des Plaines, Ill.

University City in Madrid, Spain. The school of Naval Engineering is located in the right background. One of the features of the International Congress will be the dedication of facilities by the Spanish Institute of Iron and Steel, host to the Congress. The building on the left is a students' residence.

Chicago and Birmingham Sites for Opening Courses in T&RI 1959 Technical Program

■ Four courses in February and March will open the T&RI 1959 program. Three will be held in Chicago and one in Birmingham, Ala.

The courses:

Cupola Melting of Iron, Feb. 2-6, Chicago.

Melting of Copper-Base and Light Alloys, Feb. 16-18, Chicago.

Gating & Risering of Castings, Feb. 23-25, Birmingham, Ala.

Metallography of Ferrous Metals, March 9-11, Chicago.

Cupola Melting of Iron

This course, given in Berkeley, Calif., Hamilton, Ontario, and Chicago during 1958, was attended by 132 students from Canada, Mexico and 13 states.

Included in the study will be cupola design and construction; materials purchasing and handling; charge preparation; controls, slagging; operating problems and metallurgy.

Melting of Copper-Base and Light Alloys

At the request of students, this course confined in 1958 to the melting of copper-base alloys, has been expanded to include aluminum and magnesium.

The course includes:

Classification of Alloys—Scope and basis of classification.

Melting Equipment – Basic concepts; electric furnaces including indirect arc, vertical ring, induction, high-frequency induction; fuel-fired furnaces with discussions on crucible pit lift-out types, crucible tilting furnaces, open-flame, reverberatory and cupolas.

Control of Melt Quality – Furnaces; raw materials including analysis, purchasing; composition ingot melting; effect of refractories; foreign materials; furnace atmosphere and fluxes.

Temperature Control—Pouring temperatures and removal temperatures; and measurement by pyrometers.

Testing Procedures for Quality Control—Importance; fracture tests; specific gravity, fluidity, deep-etch test and pressure testing.

Aluminum Alloys—Classification; melting equipment and the control of melt quality.

Magnesium-Base Alloys—Classification; melting equipment and control of melt quality.

Safety Practices in Melting.

Gating & Risering of Castings

This is the first of the 1959 courses to be co-sponsored with local AFS Chapters. Participating will be the Birmingham Chapter. The course has been broadened to include sections on gating and risering of non-ferrous castings.

Basic Fundamentals of All Metals—Definitions; application to gating systems; principles of solidification; casting and riser considerations for controlled solidification; fluid flow of metals.

Flow in Gating Systems and Mold Cavities—Horizontal gating research reports, AFS film "Effect of Horizontal Gating Design on Casting Quality;" AFS film "A Study of Vertical Gating Design."

Gating of Ferrous Castings—Functions of ideal gating system; establishing the system; optimum pouring time; designing a gating system; calculations of a gating system.

Risering of Ferrous Metals—Solidification of gray iron; microporosity; mold materials and risering; selection of riser size and location; maintaining riser temperature; recommendations.

Gating & Risering of Non-Ferrous Alloys—Solidification fundamentals; functions of ideal system; structure and internal shrinkage; types of gates and application;types of risers and application; choking and skimming systems; sprue, runner, ingate ratios; break-off cores; recommendations.

Metal Flow in Molds—Film from Institute of British Foundrymen.

Metallography of Ferrous Metals

This course is restricted to 25 students. Given in 1958 it includes lectures, demonstrations and a visit to Buehler, Ltd., Evanston, Ill.

Course in part consists of information from microscopic analysis, iron-carbon alloys, structural components of iron-carbon alloys, laboratory equipment and techniques, heat treatments.

1959 T&RI Courses

February-March

Subject and Description	*Dates*
Cupola Melting of Iron. . . . . Instructional course for cupola operators, supervisors, metallurgists and foremen. Basic principles for efficient cupola operation are studied with emphasis on cost reduction. Raw materials, cupola design, combustion control, metallurgy of cast iron, maintenance and new developments. Course M3A, $90, to be held in Chicago.	**Feb. 2-6**
Melting of Copper-Base and Light Alloys. . Course of instruction for melters, supervisors, metallurgists and foremen. Nomenclature, alloy classification, melting fundamentals, equipment, controls, testing and raw materials. Basic control variables are considered in light of optimum results. Course M1A, $60, to be held in Chicago.	**Feb. 16-18**
Gating & Risering of Castings. . . . . Instruction course covering theory and practice on the various problems relating to gating and risering. Metal flow, solidification phenomena, heat transfer, shrinkage, hot tears, ferro-static pressure, gate and riser design, mold wall movement and surface tension are some of the many facets considered. Intended for foremen, technicians, foundry engineers, supervisors, industrial engineers, and production and quality control personnel. Course GR1A, $40, to be held in Birmingham, Ala.	**Feb. 23-25**
Metallography of Ferrous Metals. . . . . Demonstration and workshop course for melters, supervisors, foremen, foundry engineers, researchers, laboratory technicians, metallurgists and design engineers. Basic metallurgy, terminology, phase diagrams, micro and macro analysis, physical properties based on metallographic interpretation and heat treatment are studied. One day of the course is spent on demonstrations and workshop activities in the laboratory. Metal specimens are prepared and analyzed. Course MTY1A, $80, to be held in Chicago.	**Mar. 9-11**

national news

T&RI 1958 Program Increased Both Courses and Activities

■ More personalized instruction covering a greater range of foundry subjects was presented by the AFS Training & Research Institute in 1958.

During 1957 the average enrollment was 44 students. By restricting enrollments for better instruction, the average attendance in 1958 was 31 students per class. This policy proved effective in the presentation of combination lecture and demonstration courses where one day of instruction was spent in laboratory work.

In 1957 nine courses were presented by T&RI with 13 given in 1958, drawing students from 27 states, from two Canadian provinces and one Mexican territory. Also during 1958 regional courses were given in cooperation with the Northern California and Ontario Chapters.

The five positions having the greatest frequency in 1958 enrollment were foundry foremen, foundry engineers, metallurgists, superintendents and sales engineers. These categories represented the top five in 1957 except for sales engineers moving up one position.

Students, in suggesting subjects to be included, listed the following as their ten top choices: metallurgy of gray iron, gating and risering, metallography, sand control, electric furnace practice, causes and reduction of scrapped castings, molding practice, non-destructive testing, plant layout and various cost subjects.

Questionnaires were used to guide T&RI activities. Students were asked to evaluate courses, select subjects and comment on the advisability and location of permanent facilities for laboratory-type courses.

Students overwhelmingly approved the courses and recommended permanent facilities for training courses on foundry subjects. As in 1957 most students preferred a middle west location.

Are Courses Worthwhile?

Comments from those attending 1958 T&RI courses in replying as to whether or not time and money spent were worthwhile to individuals and their company.

"This is the second course I have attended taught by AFS. Both were worthwhile."

"The instructors are certainly experts in the field—practical."

"In evaluating the time and money spent, I would say that it was a 'real bargain.'"

"Broadened my scope of thought—personally I have 25 years of foundry operation and there were 'some thoughts' broadened."

"Being relatively new in a foundry, I feel that I have received a great deal from the instruction and talking to different men about specific problems."

"The course gave an insight into other peoples opinions on the subject of sand technology. The opinions of the speakers were not always in agreement, but were helpful in understanding the many aspects of the subject."

"We should get more courses like this oftener."

"It was an excellent course and it is paying off for my company in sand control and lower scrap due to many fine points I picked up at your course."

"By going to these sessions you are kept up to date with the latest methods."

"The course served to remind us of some of the items we should be aware of but sometimes forget."

"Interchange of ideas, group sharing in solving individual problems, comparing problems and solutions and friendships developed, etc., made this course very much worthwhile."

"There were a lot of things discussed that I did not fully understand until now."

"Because of no formal training in the past, this classroom type of training was very helpful in gaining needed knowledge."

"We have improved our morning starts and raised average temperature."

"There was much to be learned—up to the individual student. I learned a great deal."

"Helped to establish what experience had taught was sound and emphasized aspects of sand testing and control that I was not aware of."

Shell Mold & Core Group Names New Committees

■ Appointments made in the Shell Mold & Core Committee of the Sand Division:

■ Sub-committee for preparing tentative procedures and representative for three new tests considered for evaluating shell molding. Chairman J. A. Terpenning, Archer-Daniels-Midland Co., Cleveland; Alex L. Graham, Harry W. Dietert Co., Detroit; Richard A. Rabe, General Motors Corp., Detroit.

■ Sub-committee to evaluate hot expansion test data for submission of tentative test for evaluating heat distortion in shell molds to the Sand Handbook Revision Committee — Chairman Alex L. Graham; R. E. Daine, Aluminum Co. of America, Cleveland; R. J. Cowles, Walworth Co., South Boston, Mass.

■ Fundamental research sub-committee to select projects in long range study on shell molding. Chairman J. M. Etherington, American Brake Shoe Co., Mahwah, N. J.; Nicholas Sheptak, Dow Chemical Co., Midland, Mich.; Theodore V. Linabury, Miller Co., Chicago.

■ Among problems suggested for long-range research were: peel back correlated with shell investment; methods of controlling shell expansion; gating and risering; variables related to shell assembly back-up; low cost additives to supplement phenolic binders; control of gaseous products during metal solidification; possibilities of double investment applying surface coatings and washes.

Discussions were conducted on:

■ Preliminary report on Armour Research work concerning effect of adding slag and feldspar to sand in shell mold usage.

■ Equipment and procedures for hot tensile testing of resin sand dry mixes or coated sand for shell molding processing. Application has been made for patent on equipment which provides for curing sand resin specimen in tensile machine and pulling while still hot at a controlled temperature.

Terpenning described modification of this in which he uses a multiple sample unit taking four specimens simultaneously and breaking all four in one tensile pull.

■ Evaluation of resin coated sand test by methods employed by various companies.

■ Preliminary description of visual crack test representative of heat application to a shell.

Deadline Nearing for Annual AFS Apprentice Competition

■ Only one month remains for competition in local apprentice contests since entries in national competition must be received by March 16.

Local contests are conducted by AFS chapters or by plants operating individually or as a group. In areas where chapters sponsor competition, plant entries must clear through that contest. Chapter or inter-plant (three or more plants) contests are encouraged since the top three entries in each division may be entered in national competition. Individual plant contests may send only one winner from each division.

As of December chapters holding local competition included Central Ohio, Corn Belt, Detroit, Northeastern Ohio, Northwestern Pennsylvania, Oregon, Philadelphia, St. Louis, Southern California, Washington and Wisconsin.

Examples of inter-plant competition are found in the wood patternmaking contest where apprentices from Caterpillar Tractor Co., Peoria, Ill., are competing with those from International Harvester Co., Canton, Ill., Gem City Pattern Co., Quincy, Ill., and Toluca Pattern Works, Toluca, Ill.

Also in the same division are members of the Akron Patternmakers Joint Apprentice Commission which has apprentices from State Foundry Co., Standard Pattern Works, Akron Pattern Works, Goodrich Tire & Rubber Co., Adamson United and Arrow Pattern Works of Akron, Ohio, as well as Newton Brass Foundry, Barberton, Ohio, and Summit Pattern Works, Greensburg, Ohio.

Several in-plant contests are being held, particularly in the metal-patternmaking division. These include Whitin Machine Works, Whitinsville, Mass.; Chevrolet-Saginaw Grey Iron Foundry, Saginaw, Mich.; Crane Co., Chicago; and Caterpillar Tractor Co., Peoria, Ill.

Despite the limited time available to conclude local contests, AFS Education Director R. E. Betterley points out that contests can be conducted within a month if no time is lost in securing the necessary details and materials from the Central Office. This is particularly true in the molding division where the contestant simply makes a green sand mold from the official pattern.

Rules and regulations provide that all chapters and plants holding local contests must:

- Furnish name of one person to act as the official contact.
- Address all correspondence only to AFS Education Director, Golf & Wolf Roads, Des Plaines, Ill.
- Furnish Education Director with type of contest, full names of contestants, companies and respective divisions of entry of all intended contestants.
- Enter on contest identification tags only the contestant's registry number assigned by AFS, time consumed in completing entry and, with casting entries only, the gross weight and approximate metal analysis.

Winning entries must be shipped only to Prof. R. W. Schroeder, University of Illinois, Navy Pier, Chicago, Ill. Do not ship to AFS Central Office in Des Plaines, Ill. For tracing purposes, written notification should be sent to Schroeder at the time of shipment.

All entries must be received not later than 5:00 pm Monday, March 16. Transportation charges on all entries must be prepaid.

Contestants desiring return of their entries must make this request to the Central Office at the time of shipment.

Administrators of local contests are urged to adhere strictly to the official rules and regulations.

Foremen Lead T&RI Registration

■ More foundry foremen attended 1958 T&RI courses than any other group. Others in the top five were foundry engineers, metallurgists, superintendents and sales engineers.

Suggest Possible Research Projects

■ Possible research projects for the Die Casting & Permanent Mold Division were discussed at the December meeting of the division's Research Committee.

Six possibilities were advanced for die casting:

- Die lubricants.
- What can temperature control of the die accomplish?
- Gating.
- Venting.
- Vertical shot machines.
- Vacuum systems with intensified pressures.

It was recommended that such projects as temperature control of dies should be placed in a plant equipped with experimental machines comparable in size to production units. Six such organizations were suggested.

Three possible projects were advanced for permanent mold investigation.

- Thermal control.
- Mold coatings.
- Mold design to prolong life and improve thermal behavior.

In addition it was suggested that a test be developed for evaluating die or permanent mold alloys for their tendency to develop hot tears.

Most Popular Subjects

■ The five most poular subjects according to frequency on 1958 T&RI questionnaires were Metallurgy of Gray Iron; Gating & Risering; Metallography; Sand Control, Molding and Core and Electric Furnace Practice.

Going over the details of 1959 Penn State Foundry Conference to be held June 25-27 at University Park, Pa. are: program co-chairman **T. E. Egan,** Cooper-Bessemer Corp., Grove City, Pa.; vice-chairman **C. W. Mooney, Jr.,** Olney Foundry, Link-Belt Co., Philadelphia; **W. B. Wallis,** Lectromelt Furnace Div., McGraw-Edison Co., Pittsburgh, Pa.; secretary **W. P. Winter,** Pennsylvania State University; general chairman **E. J. Biller,** Vulcan Mold & Iron, Latrobe, Pa.; treasurer **H. P. Good,** Textile Machine Works, Reading, Pa.; program co-chairman **H. C. Erskine,** Aluminum Co. of America, Pittsburgh, Pa.; **Bryce Gray,** Pennsylvania State University.

national news

Foundry Industry Tells Story at Castings Show

"Today's progressive foundries are linking production advancement with merchandising," says W. N. Davis, AFS Exhibit Manager. "Every foundry has a story to tell—the industry's leaders are doing just that," points out Davis.

The AFS Engineered Castings Show is the ideal place for the industry to not only tell its story, but more important, to show what can be done with cast metals.

Every effort has been devoted to making the Engineered Castings Show the show place of the industry. To bring the designers and buyers of castings together with the foundrymen.

Exhibitors have been limited to categories dealing with the production of castings and patterns and quality control.

What will designers and buyers see?

FERROUS CASTINGS—gray iron, malleable iron, steel and ductile iron.

NON-FERROUS CASTINGS—Aluminum, magnesium, titanium, zinc alloys and brass and bronze.

PROCESSES—Sand, shell mold, precision investment, centrifugal, cement mold, plaster mold and pressure mold.

CASTINGS METALS AND ALLOYS—Primary and secondary metals and their alloys. Ferrous metals and their alloys.

QUALITY CONTROL EQUIPMENT—Inspection devices, metallurgical analysis, non-destructive testing, physical testing and stress analysis.

PATTERNS—Wood, metal, plastic and ceramic.

Partial list of exhibitors:

Aluminum Co. of America, Pittsburgh, Pa.
American Brake Shoe Co., Engineered Castings Div., New York.
American Smelting & Refining Co., New York.
American Steel Foundries, Chicago.
Apex Smelting Co., Chicago.
Morris Bean & Co., Yellow Springs, Ohio.
Bendix Aviation Corp., Teterboro, N.J.
Brillion Iron Works, Inc., Brillion, Wis.
Brush Beryllium Co., Cleveland.
Buckeye Brass & Mfg. Co., Mansfield, Ohio.
Chicago Foundry Co., Chicago.
Curto-Legonier Foundry, Melrose Park, Ill.
Dixie Bronze Co., Birmingham, Ala.
Doehler Jarvis Div., National Lead Co., Toledo, Ohio.
Dow Chemical Co., Midland, Mich.
Hampden Brass & Aluminum Co., Springfield, Mass.
East St. Louis Castings Co., East St. Louis, Ill.
Engineered Precision Casting Co., Matawan, N.J.
Fabricast Div., General Motors Corp., Bedford, Ind.
Gillett & Eaton, Inc., Lake City, Minn.
Benj. Harris & Co., Chicago Heights, Ill.
Kaiser Aluminum & Chemical Sales, Inc., Chicago.
Keokuk Steel Casting Co., Keokuk, Iowa.
H. Kramer & Co., Chicago.
R. Lavin & Sons, Inc., Chicago.
Lindgren Foundry Co., Batavia, Ill.
Love Bros., Inc., Aurora, Ill.
Lynchburg Foundry Co., Lynchburg, Va.
Magnaflux Corp., Chicago.
Motor Castings Co., Milwaukee.
Neenah Foundry Co., Neenah, Wis.
Nonferrous Foundries, Inc., Indianapolis.
Paxton-Mitchell Co., Omaha, Neb.
Pelton Steel Castings Co., Milwaukee.
Quality Aluminum Casting Co., Waukesha, Wis.
Roessing Bronze Co., Pittsburgh, Pa.
Rolle Mfg. Co., Lansdale, Pa.
Scientific Cast Products Corp., Cleveland.
Shaw Process Development Corp., Div. British Industries Corp., Port Washington, N.Y.
Sipi Metals Corp., Chicago.
Sivyer Steel Casting Co., Milwaukee.
Southern Precision Pattern Works, Inc., Birmingham, Ala.
Stahl Specialty Co., Kingsville, Mo.
Superior Foundry, Inc., Cleveland.
Swedish Crucible Steel Co., Detroit.
Universal Castings Corp., Chicago.
Universal Foundry Co., Oshkosh, Wis.
Waukesha Foundry Co., Waukesha, Wis.

Two AFS Gating Films Available

■ Two new 16 mm, color, sound motion pictures dealing with gating design are now available to AFS Chapters. Both are based on AFS sponsored research and have running time of approximately 40 min. each. The films:

Effect of Gating on Casting Quality —Horizontal Gating—The third on this subject including highlights of previous work and more recent experimental results obtained since completion of the second film.

A Study of Vertical Gating Design —Based on developing a design for improved vertical-gating system applicable to molds encountered in commercial practice.

These investigations were conducted by studying the flow characteristics of water poured into transparent plastic molds of various gating systems.

A charge of $20 is made for each showing of the films which are shipped air express, collect and should be returned prepaid, air express.

Name Officers for Ductile Sessions

■ Ductile Iron Division presiding officers for the 1959 Castings Congress have been selected. The division will present two technical sessions, a shop course and co-sponsor a luncheon with the Gray Iron Division.

Tensile Properties of As-Cast and Annealed Ductile Iron. Application of Ductile Iron.

Co-Chairman—C. K. Donoho, American Cast Iron Pipe Co., Birmingham, Ala.; A. W. Anderson, International Harvester Co., Chicago.

Secretary—L. J. Venne, Electro Metallurgical Co., Div. Union Carbide Corp., Cleveland.

Heat Treatment of Ductile Iron. Carbon Flotation.

Co-Chairmen—K. D. Millis, International Nickel Co., New York; H. W. Ruf, Grede Foundries, Inc., Milwaukee.

Secretary—George Krumlauf, Republic Steel Corp., Cleveland.

Shop Course Committee

Co-Chairmen—S. S. Phillips, Sibley Machine & Foundry Corp., South Bend, Ind.; Eric Welander, John Deere Malleable Works, East Moline, Ill.

Secretary—C. R. Isleib, International Nickel Co., Chicago.

Wisconsin University Offers Two-Day Seminar on Non-Destructive Testing

■ A two-day non-destructive testing seminar will be held Feb. 5-6 at the Wisconsin Center Building, University of Wisconsin, Madison, Wis. The course, *Non-Destructive Testing Techniques*, is sponsored by the Extension Service of the University's Department of Engineering.

A $20 fee is charged for the course. The program:

THURSDAY, FEB. 5

8:30 am – Registration
9:00 am – Welcome
9:15 am – Radiography
10:45 am – Nucleonic Gaging Methods
12 noon – Lunch
1:15 pm – Fluorscopic Inspection Techniques
2:45 pm – Penetrant Inspection
4:00 pm – Adjourn until dinner.
6:30 pm – Dinner Meeting

FRIDAY, FEB. 6

9:00 am – Magnetic Particle Inspection
10:30 am – Eddy Current Test Methods
11:45 am – Lunch
1:00 pm – Ultrasonic Inspection, Reflection and Contact Techniques
2:30 pm – Ultrasonic Inspection, Immersed Techniques
3:45 pm – Presentation of Certificates
4:00 pm – Final Adjournment

Ten Speakers to Address Foundrymen at Southeastern Regional Conference

■ Ten technical speakers will address foundrymen attending the 27th Southeastern Regional Foundry Conference to be held Feb. 26-27 at the Tutwiler Hotel, Birmingham, Ala.

The conference is sponsored by the AFS Birmingham District Chapter, Tennessee Chapter and University of Alabama Student Chapter. Birmingham Chapter Chairman M. D. Neptune, National Works, James B. Clow & Sons, Birmingham, Ala., will be conference general chairman. Birmingham Chapter Vice-Chairman J. R. Cardwell, Stockham Valves & Fittings, Inc., Birmingham, Ala., is the conference program chairman.

The program includes plant visits, a luncheon on the opening date, a ladies program and a banquet on Friday evening.

The tentative program:

THURSDAY, FEB. 26

9:00 am Registration.
10:00 am *How to Get the Most Out of Your AFS and the Regional Conference*, AFS General Manager Wm. W. Maloney.
11:00 am Subject and speaker to be announced.
12:30 pm Luncheon.
2:00 pm *Noise in the Foundry*, Floyd E. Frazier, National Association of Mutual Casualty Companies, Chicago.
3:00 pm *The Gating and Risering of Castings*, Clyde M. Adams, Jr., Massachusetts Institute of Technology, Cambridge, Mass.
4:00 pm Speaker and subject to be announced.

FRIDAY, FEB. 27

9:00 am Plant visitations.
1:30 pm *Direct Reduction Processes for Cast Iron*, H. W. Lownie Jr., Battelle Memorial Institute, Columbus, Ohio.
1:30 pm *Gating and Risering of Brass and Aluminum*, R. A. Colton, Federated Metals Div., American Smelting & Refining Co., Houston, Texas.
2:30 pm *Burher Automated Molding and pouring Method, Alex H. Homberger*, International Automation Corp., Ann Arbor, Mich.
3:30 pm *Cold Setting Core Binders*, Daniel R. Chester, Archer-Daniels-Midland Co., Cleveland.
3:30 pm *Causes and Correction of Non-Ferrous Casting Defects*, Ray Cochran, R. Lavin & Sons, Inc., Chicago.
7:00 pm Annual Banquet—speaker, AFS President L. H. Durdin.
Toastmaster, Warren Whitney, James B. Clow & Sons, Birmingham, Ala.

Mold Surface Sub-Committe to Edit Report on Investigations

■ A report on penetration experiments with iron, aluminum, and 85-5-5-5 brass will be edited by a three-man sub-committee of the Sand Division Mold Surface Committee. Work with Wood's metal, magnesium and lead will appear as an appendix.

Members are: C. E. McQuiston, Advance Foundry Co., Dayton, Ohio; R. W. Ruddle, Foundry Services, Inc., Columbus, Ohio; J. B. Caine, consultant, Cincinnati.

A comparison of existing surface measuring methods, visual comparator, plastic replica, microscopic and stylus will be made by a three-man sub-committee. Members are: McQuiston, Caine and J. E. Haller, Coshocton Works, James B. Clow & Sons, Inc., Coshocton, Ohio. The sub-committee will compare the methods using samples already cast and measured with a profilometer.

It was agreed that all subsequent research use a stylus type instrument as a means for measuring surface finish, and that when other measuring methods are used they will be compared with stylus measurements.

Texas Regional Set for March

■ Latest developments in the foundry industry will be brought to southwestern foundrymen at the Texas Regional Conference to be held March 19-20 at the Menger Hotel, San Antonio, Texas.

The conference, sponsored by the Texas Chapter, will have as its theme "Modern Technology Adapted to Southwestern Foundry Operations." C. R. McGrail, Alamo Iron Works, San Antonio, Texas, will serve as conference general chairman with Edwin E. Pollard, Western Foundry Co., Tyler, Texas and Elmore C. Brown, Whiting Corp., Houston, Texas, acting as co-chairmen of the program committee.

A ladies program has been scheduled which includes a style show, cruise on the San Antonio River, visits to historical sites and the evening barbeque and banquet.

The program:

THURSDAY, MARCH 19

8.00 am Registration.
10.00 am General Meeting.
12:30 pm Luncheon.
2:00 pm Steel, non-ferrous and cast iron sessions.
3:40 pm Steel, non-ferrous and cast iron sessions.
7:00 pm Barbeque.

FRIDAY, MARCH 20

9.00 am General Meeting.
12:30 pm Steel, non-ferrous and cast iron round table meetings.
3:40 pm Steel, non-ferrous and cast iron sessions.
7:15 pm Banquet.

Cradle of Texas liberty, the **Alamo**, located in heart of San Antonio. Menger Hotel, site of the **Texas Regional Conference**, is shown in background.

national news

Report on Factors Affecting Finish

■ Conclusions regarding surface finish of non-ferrous castings based on British research have been sent to members of the AFS Sand Division Mold Surface Committee.

The report, *Surface Finish for Non-Ferrous Castings*, appeared in the Jan. 1959 issue of *The British Foundryman*. Due to the length of the article the conclusions were furnished to the committee, rather than the entire report.

Authors' conclusions: It has been found that the surface finish of all non-ferrous castings investigated:

- Improves progressively with increasing fineness of the molding material. Relationships between the surface finish, and the permeability and AFS fineness number of the sand have been established.
- Improves with the degree of ramming or compaction of the molding material, and a reasonable correlation exists between surface finish and the surface density of mold or core.
- Is influenced adversely by increasing hydrostatic head and there would appear to be a critical head height above which penetration occurs.
- May be substantially improved by the use of coatings, especially those based on flake-like minerals.
- Depends upon the alloy composition. Generally, those alloys forming a tenacious oxide skin result in a better finish.
- Depends upon the binders employed. Binders resulting in high flowability of the sand, invariably result in a better surface finish.
- Is influenced by the degree to which the sand has been used and by certain mold additions although the influence of these two variables is slight compared to those listed above.
- Is not influenced appreciably by the degree of venting, pattern quality within reasonable limits, many sand additions, by the drying of the sand, and by pouring temperature as long as metal penetration is absent.
- It is possible to assess the surface finish of non-ferrous castings quantitatively by touch, using a series of numbered standards for comparison.

International Attendance

■ In 1958 a total of 368 students attended T&RI courses, drawing from 27 states, two provinces in Canada and one territory in Mexico.

Tentative Schedule of Technical Sessions
AFS Castings Congress & Engineered Castings Show
April 13-17, 1959 . . . Hotels Sherman & Morrison

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8:00 am	Authors Breakfast	Authors Breakfast	Authors Breakfast	Authors Breakfast	Authors Breakfast
8:30 am	Registration opens 8:00	Registration opens 8:30	Registration opens 8:30	Registration opens 8:30	Registration opens 8:30
9:00 am	Exhibits open 9:00-5:30	Exhibits open 9:00-5:30		Exhibits open 9:00-5:30	Exhibits open 9:00-4:00
9:30 am to 11:30 am	Light Metals Malleable Pattern	Brass & Bronze Pattern Malleable SH&AP T&RI Trustees	Annual Business Meeting & Hoyt Lecture Exhibits open 11:30-5:30	Steel Ductile Iron Fundamental Papers Die Casting & Permanent Mold	Sand Heat Transfer Ductile Iron Fundamental Papers
12:00 noon	Light Metals Luncheon Malleable Luncheon	Brass & Bronze Luncheon Pattern Luncheon Board of Directors Luncheon & Meeting	Management Luncheon Die Casting & Permanent Mold Luncheon	Steel Luncheon Ductile and Gray Iron Luncheon Past Presidents Luncheon	
2:00 pm to 4:00 pm	Brass & Bronze Sand Pattern	Light Metals Education Industrial Engineering & Cost	Steel Die Casting & Permanent Mold Gray Iron	Sand Heat Transfer Ductile Iron Fundamental Papers	Gray Iron Plant & Plant Equipment
4:00 pm to 5:30 pm	Brass & Bronze Malleable Shop Course	Sand Light Metals Malleable Shop Course Gray Iron Shop Course	Industrial Engineering & Cost Die Casting & Permanent Mold Gray Iron Shop Course Sand	Steel Gray Iron	
6:00 pm		Sand Dinner			
7:00 pm		Canadian Dinner	Annual Banquet	Alumni Dinner	
8:00 pm to 10:00 pm	Sand Shop Course				

chapter news

Texas Chapter

Meets with Student Chapter

■ Texas Chapter members and the Texas A & M Student Chapter met in December at College Station, Texas, to hear John Kimes, Lufkin Foundry & Machine Co., Lufkin, Texas, discuss *Ferrous Metallurgy*.

Kimes explained composition, methods of manufacture and physical properties of gray iron, malleable iron and ductile iron. Slides were used to illustrate the various forms of graphitic carbon in different types of cast iron.

—H. H. Judson

Tri-State Chapter

Brings Gifts for Children

■ Each couple attending the chapter's annual Christmas party brought a gift for an under-privileged child. The gifts were distributed by the Salvation Army. More than 200 members and guests attended the party held at the Mayo Hotel, Tulsa, Okla.

—Leslie O'Brien

Major Prout, Salvation Army, Tulsa, Okla., accepts gifts from Tri-State Chapter Chairman **E. F. Hines.** Gifts were donated by couples attending annual Christmas party.

How Others Are Doing It

Membership

Western New York — Conducts a membership contest running Oct. 3-March 6 based on a credit point system awarding one point for affiliate or associate membership, two points for personal membership and six points for company membership. Five prizes are awarded; 1st, two years dues or $40; 2d, 1 years dues or $20; 3d, $10; 4th, Gold AFS member pin; 5th, silver AFS member pin.

Chicago — Puts emphasis on personal contacts with dropped members.

Publications

Eastern Canada — Emphasises one AFS publication at each meeting. The book is displayed, contents explained and book awarded as door prize.

International Meeting Held by AFS Chapters

■ AFS Detroit and Ontario Chapters held a fall international meeting in Detroit. Approximately 250 members attended with 50 coming from Canada.

The afternoon was devoted to plant visits at the Cadillac Motor Co. and City Pattern Co. D. S. Harder, Ford Motor Co., discussed progress in the foundry.

—V. H. Furlong

Arrangements Chairman **B. P. Glover** and wife (fourth couple from left) shown with Tri-State officers and wives. Left to right: Mr. and Mrs. **William Pitts,** Mr. and Mrs. **Jackson Dean,** Mr. and Mrs. **Emmett Hines,** Mr. and Mrs. **Harry Ferlin.** *—Leslie O'Brien*

Central Indiana Chapter

Combine Directors Meeting, Tour

■ Officers and directors of the Central Indiana Chapter combined a directors meeting and plant visit Nov. 14-15 at the Wheelabrator Corp. plant, Mishawaka, Ind.

The tour included visits to the equipment fabrication plant, steel shot plant and demonstration and research facilities.

Officers attending were:

Chairman W. H. Faust, Electric Steel Castings Co., Indianapolis.

Vice-Chairman W. E. Boyd, Mexico Refractories Co., Indianapolis.

Secretary J. B. Essex, Golden Foundry Co., Columbus, Ind.

Treasurer T. E. Smith, Central Foundry Div., GMC, Danville, Ill.

Others attending were:

W. M. Fitzsimmons, International Harvester Co., Indianapolis.

William Grimes, Gartland Foundry Co., Terre Haute, Ind.

Harry J. Frank, Frank Foundries Corp., Muncie, Ind.

Arthur R. Lindgren, Jr., Magnaflux Corp., Indianapolis.

Eugene E. Wene, Link-Belt Co., Indianapolis.

Warren Ballantine, Haynes Stellite Co., Kokomo, Ind.

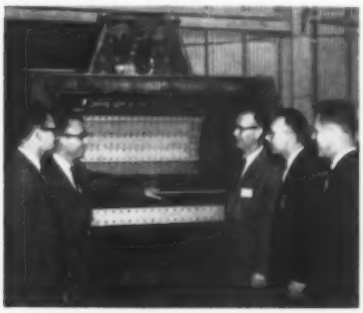
Howard Gooden, Muncie Malleable Iron Co., Muncie, Ind.

A. R. Downey, International Harvester Co., Indianapolis.

Jack Sickmann, Swayne Robinson Co., Richmond, Ind.

John O. Hastings, Electro Metallurgical Co., Indianapolis.

Arrangements for the tour were made by Central Indiana Membership Chairman George W. Dehn, Wheelabrator Corp. Conducting the tour were A. B. Stevens, G. O. Pfaff, G. E. Medlock, S. A. Hearrell, V. S. Spears of Wheelabrator Corp.



Inspecting partially-assembled cleaning machine are **W. E. Boyd, George W. Dehn, J. B. Essex, W. H. Faust** and **G. O. Pfaff.**

chapter news

Paul E. Retzlaff has served as secretary of the **St. Louis Chapter** for the past 12 years. Retired after 39 years with Nordberg Mfg. Co., Retzlaff now works on a reduced schedule for Warren Sand Co. and Midwest Foundry Supply Co. Is this a record for continuous chapter service?—*H. V. Boemer*

Vernon J. Sadler, Saginaw Valley Chapter Chairman 1957-58 (left) receives plaque from Chapter Chairman **Arthur H. Karpicke.**

Olney Foundry Div., Link-Belt Co., Philadelphia is well represented at each meeting. Superintendent **C. W. Mooney, Jr.** and a dozen supervisors attend monthly. Left to right: **John Schraeder, Lloyd Clifford, William Roberts** and **Wayne Watson.**

Northeastern Ohio Chapter

High-Strength Castings Talk

■ Work on the production of steel investment castings with up to 300,000 psi ultimate tensile strength and aluminum castings with more than 40,000 psi ultimate tensile strength was described at the October meeting by Robert J. Ely, American Brake Shoe Co.

Production of such castings is based on extremely rigid control of metal analyses and control of foundry practices. These castings, he stated, not only can compete with wrought metals but can exceed their properties. Applications to date have been in the aircraft and missile fields but it is expected that commercial applications will develop as their production increases.—*Jack C. Miske*

Official greeter for the **Western New York** Chapter is **Gene Zapfel,** Pratt & Letchworth Co., Buffalo, N. Y.—*Walter Napp*

Pneumatic handling of sand was discussed at the September meeting of the St. Louis Chapter by **George Anselman,** Whirl-Air-Flow Corp., Minneapolis. Photo shows Anselman addressing chapter. Seated is Technical Chairman **Lester Segar,** General Steel Castings Corp., Granite City, Ill.—*H. V. Boemer*

New Officers for Pittsburgh Chapter are: President I. W. Sharp, American Steel Foundries, Verona, Pa.; Vice-President **James D. Wilson,** Bronze Die Casting Co., Pittsburg, Pa.; Secretary-Treasurer **E. P. Buchanan,** Pittsburg, Coke & Chemical Co., Pittsburg, Pa. —*Walter Napp*

New Company Members

Olin Aluminum, Div. Olin Mathieson Chemical Corp., New York (Metropolitan Chapter).

Falcon Foundry Co., Lowellville, Ohio (Northeastern Ohio Chapter).

Pacific States Steel Corp., Niles, Calif. (Northern California Chapter).

Related, who's related? **W. S. Thomas Sr.,** and **W. S. Thomas, Jr.,** both of Emmaus Foundry & Machine Co., Emmanaus, Pa. appearing at meeting of **Philadelphia** Chapter.
—*Leo Houser and E. C. Klank*

Northwestern Pennsylvania Chapter starts them out young. **T. B. Bueg,** takes over the reception desk.

—*Walter Napp*

H. F. Bishop (right), Exomet Co., Conneaught, Ohio, outlined design, gating and risering problems related to non-destructive standards at the Chicago Chapter. **Pat Dempsey,** Kensington Steel Co., Chicago, was technical chairman.

Northwestern Pennsylvania Christmas committee. Seated: **William J. Miller,** Frederic B. Stevens, Inc.; **W. D. Hodge,** W. S. Hodge Foundry, Inc.; **Howard Diemert,** Erie Bronze Co.; **Mrs. and Mr. O. C. Bueg,** Arrow Pattern & Engineering Co. Standing: **James J. Markowitz,** Cascade Foundry Co.; **Jake Diemert,** Erie Casting Co.; **Pete Pascale.**

Carl Larson, Reliance Pattern Works, Chicago, buys ticket from Chicago Chapter Secretary **Richard M. Frazier,** Hickman, Williams & Co., Chicago. Larson was technical chairman for the non-ferrous and pattern division meeting.

Foundry superintendent **W. W. Goessel** (far right) and other Beloit Eastern Corp., Downington Pa. workers who travel 50 miles to attend regular **Philadelphia** Chapter meetings.

Design and operation of a slurry system was presented at the Chicago Chapter meeting by **Ted Linabury,** Miller & Co., Chicago (left). **George DiSylvestro,** American Colloid Co., Skokie, Ill., operated slides for Linabury and tape recorded two other technical talks.

Northwestern Pennsylvania Chapter officers: Vice-chairman **William E. Eccles,** Cooper Bessemer Corp., Erie, Pa.; Chairman **W. S. Hodge,** W. S. Hodge Foundry, Inc., Greenville, Pa.; Secretary **Stanley Trezenski,** Weil-McLain Co., Erie, Pa. Lectern was made up by pattern shop of Cooper-Bessemer Corp.—*Walter Napp*

men, members and their affiliation.

Committees in the Chicago Chapter include nominating, Robert E. Kennedy Scholarship Fund, reception, membership, education, gray iron, malleable, maintenance, nonferrous, pattern, steel, entertainment, directory, publicity, apprentice and auditing.

Waiting for **Pittsburgh Chapter** November meeting to start are **H. E. Gebhard** and **W. E. Holsinger,** Blaw-Knox Corp.

Chicago Organizational Chart Shows How Chapter Functions

■ A better understanding of how the Chicago Chapter functions is provided through an organizational chart recently compiled.

The 11x17 in. chart indicates the chapter officers and directors and various committees including chair-

AFS Vice-President **C. E. Nelson** spoke at November meeting of **Saginaw Valley** Chapter.

chapter news

Chapter officers and wives attending the **Northwestern Pennsylvania** Christmas party are Secretary **S. Trozenski** and wife; Treasurer **R. M. Wheatley** and wife; Chairman **W. S. Hodge** and wife; Vice-Chairman **W. E. Eccles** and wife. *—Walter Napp*

More than 250 members and guests of the **Northwestern Pennsylvania** Chapter attended the annual Christmas party held in Erie, Pa.

St. Louis Chapter members at the October meeting heard **M. H. Horton,** Deere & Co., Moline, Ill., discuss *Shell Core Application, Economics and Problems.* Technical Chairman **Jack Thompson,** Bodine Pattern & Foundry Co., St. Louis, congratulates speaker Horton (left). *—Vince Boemer*

Central New York Chapter

Foundry Noise Problems

■ Typical foundry noises and methods to reduce them were explained in an illustrated lecture by H. J. Weber, AFS Director of Safety, Hygiene and Air Pollution Control. Weber described noise levels produced by foundry equipment and ways in which they can be reduced.

—T. B. DeStafani

Northeastern Ohio Chapter

Modern Inspection Techniques

■ Modern inspection methods were discussed at the November meeting by a seven-man panel with George A. Purdy, Aluminum Co. of America, serving as moderator. Fourteen foundry and pattern instructors from local high schools were guests.

Gaging problems were discussed by J. E. Jenkins, National Aeronautical and Space Administration and N. J. Connavino, TurboTronics Corp. Jenkins described problems involved in testing turbine blades and Connavino explained modern methods of measuring curves.

L. S. Cameron, Thompson Ramo Woolridge, Inc., explored the use of x-rays and gamma rays as inspection tools and G. P. Stanhope, General Electric Co., outlined the types of equipment available. A similar treatment of magnetic particle inspection was handled by R. M. Baker, Cleveland Diesel Div., GMC, and R. N. Baughman, Magnaflux Corp.

F. C. Leone, Case Institute of Technology, described statistics for quality assurance. *—Jack C. Miske*

Western Michigan Chapter

Green Sand Fundamentals

■ It is not the process that makes for better castings and better casting finish, but the effort and the urge to do better combined with knowhow. This observation was made by C. A. Sanders, American Colloid Co., Skokie, Ill., before the December meeting of the Western Michigan Chapter.

There are many direct reasons for better casting finish, surface and tolerance in green sand molding. Perhaps the base sand grain is the most important factor—the finer the base sand, the better the casting texture. The additions blended into the sand are of equal importance.

Closer tolerances follow good foundry practice with correct supervision and control.

"Green sand molding is presently doing a better job than recent publicized molding processes with the least amount of cost attached to green sand," Sanders told the audience.

—Dan Connell

Saginaw Valley Chapter

Properties of Metals

■ Structure and physical properties of metals were outlined at the December meeting by AFS Technical Director S. C. Massari.

Massari stressed the effect on the physical properties of iron by superheating and supercooling, changing of the matrix and size and form of carbon present. He emphasized the need for strict control in heat treating, annealing and stress relieving.

—John R. Fraker

Inspecting plastic molds and patterns at **Michiana Chapter** December meeting are **Lloyd Oye,** Rezolin Co.; Technical Chairman **Robert Hull,** Casting Service Corp., La Porte, Ind.; **Robert Slack,** Federal Bryant Machine Co., South Bend, Ind.; **Henry Trimble,** Torrington Co., South Bend, Ind.; and **Tom Johnson,** Weil McLain Co., Michigan City, Ind. The speakers explained the use of plastics in pattern and corebox construction. —*Walt Ostrowski*

Northeastern Ohio Chapter

Holds Technical Symposium

■ A technical symposium on solidification and heat treatment of cast metals will be held on four consecutive Tuesdays, Feb. 24-March 17, at Case Institute of Technology, Cleveland.

No charge will be made for attending the classes. Prof. J. F. Wallace, Case Institute of Technology, is general chairman.

The program:

Feb. 24 *Review of Solidification and Heat Treatment,* J. F. Wallace.

March 3 *Copper Base Alloys,* W. L. Rudin, Elesco Smelting Corp., Chicago.

March 3 *Aluminum and Magnesium Alloys,* E. E. Stonebrook, Aluminum Co. of America, Cleveland.

March 10 *Steel and Malleable Iron,* B. C. Yearley, National Malleable & Steel Castings Co., Cleveland.

March 17 *Gray Iron, Ductile Iron and Alloy Irons,* R. A. Clark, Electrometallurgical Co. Div. Union Carbide Corp., Cleveland.

Twin City Chapter

Conducts Joint Meeting

■ The annual joint meeting of the AFS Twin City Chapter and the A. S.M. Minnesota Chapter was attended by more than 125 members and guests.

F. G. Emrich, Schleh Associates, Inc., Minneapolis, spoke on *Results Management,* telling how management consultants serve commerce and industry.

Twin City Chapter Chairman R. J. Mulligan, Archer-Daniels-Midland Co Minneapolis, served as general chairman. Twin City Chapter Vice-Chairman C. DeLaittre, Minneapolis Electric Steel Castings Co., Minneapolis, introduced the speaker.

—*J. David Johnson*

Members of the Cleveland Board of Education attended the **Northeastern Ohio** Chapter Christmas party. Center table includes **D. C. Courtright,** president, Max S. Hayes Trade School, **M. Wach,** treasurer, Cleveland Board of Education; **John Fintz,** superintendent of Special Schools; **John Matia,** purchasing agent; **Ralph Jones,** Max S. Hayes Trade School and **Frank Cech,** Max S. Hayes Trade School. Cech, nearest camera on right is head of the Hayes patternmaking division. —*Harold Wheeler*

Canton Chapter

Air Pollution and Foundries

■ Recent important air pollution laws affecting foundries was explained at the December meeting by H. J. Weber, AFS Director of Safety, Hygiene and Air Pollution Control. Foundrymen were warned that they must be alert to legislative proposals and be prepared to contest laws which would be unfair to the industry.

Weber also explained how the Central Office is prepared to assist chapters in matters dealing with air pollution legislation. —*Wendell Snodgrass*

H. J. Weber (right) AFS Director of Safety, Hygiene and Air Pollution Control discusses current air pollution legislation with **A. E. Alexander,** Rockwell Mfg. Co., Barberton, Ohio, at December meeting of **Canton Chapter.**

British Columbia Chapter

Die and Permanent Mold Alloys

■ Development of aluminum alloys for die and permanent-mold casting was outlined at the November meeting by John J. Stobie, Apex Smelting Co., Long Beach, Calif.

Stobie discussed the commonly used copper-silicon and silicon-magnesium type alloys, turning later to the high-strength alloys, based on binary combination of zinc and magnesium and the ternary combinations of zinc, magnesium and aluminum. Considering the effect of certain residual or contaminating elements, he stated that zinc, in small percentages, has been found to be less detrimental to the corrosion resistance and elongation of the copper-silicon alloys than supposed.

The speaker commented in the piston-type alloys, especially the hypereuctetic silicon alloys with lower coefficients of expansion, the anticipated use of aluminum alloys for engine blocks and the problems of fluxing off the heavy impurities and the prevention or minimizing of sludge formation. —*A. W. Greenius*

chapter news

Warner B. Bishop, Archer-Daniels-Midland Co., Cleveland, second from left, addressed **Ontario Chapter** on *What Core Process?* Others are Chapter 2d Vice-Chairman **M. D. Bleaken,** Electro Metallurgical Co., Div. Union Carbide Canada, Ltd., Toronto, Ont.; Chairman **J. M. Hughes,** Stevenson & Kellogg, Ltd., Toronto, Ont.; AFS National Director **J. H. King,** Archer-Daniels-Midland Co., Toronto, Ont.
—Vincent H. Furlong

Western New York Membership Chairman **Lynford C. Roberts** holds poster placed in all foundries in chapter area to promote membership. The chapter is promoting a membership contest based on a credit point basis.

Herbert von Wolff, Shalco Corp., Palo Alto, Calif., discussed *Development of Shell Core Process* at the December meeting of the **Western New York Chapter. Robert E. Lumley** (right) Buffalo Pipe & Foundry Co., Buffalo, N.Y., served as technical chairman.
—Walter Napp

New England Holds Annual Ladies Night

Mr. and Mrs. **Robert Brandt** and Mr. and Mrs. **Ahti Erkkinen.**

Mr. and Mrs. **Harry Sleicher** and guests.
—F. S. Holway and Tim Saunders

Mr. and Mrs. **Lawrence Parker,** Mr. and Mrs. **Robert Barker** and Mr. and Mrs. **Joseph Tata.**

Mr. and Mrs. **Paul Osborn.**

Mr. and Mrs. **William Naughton** and Mr. and Mrs. **Jack Orrok.**

Mr. and Mrs. **Alec Beck** and guests at New England's 2d Annual Ladies Night.

Foundry Educational Foundation awards were presented at recent **Chicago Chapter** meeting by **C. V. Nass** (right) Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago and F.E.F. past president. Left to right: **Alexander Zeumer, Fred Sadowski, Charles Rosengren, Phil Burnstein, Thomas Steffen** and Prof. **Roy Schroeder,** University of Illinois, Navy Pier, Chicago. *—N. C. Baranov*

Clyde A. Sanders (right) American Colloid Co., Skokie, Ill., discusses talk on *What European Foundrymen are Doing* with Chicago Chapter Chairman **D. G. Schmidt,** H. Kramer & Co., Chicago, and Chapter Vice-Chairman **John Mulholland,** Pettibone-Mulliken Corp., Chicago. Sanders' talk was based on his recent European travels.

AFS student members from Chicago Undergraduate Division, University of Illinois, Navy Pier Branch, Chicago, attending Chicago Chapter meeting with Prof. Roy W. Schroeder. Front row: **Phil Burnstein, James Sketa, Prof. R. W. Schroeder, Leo Stand.** Middle row: **Fred Sadowski, Charles Mitamura, Howard Furer, Norman Erickson, Samuel Caminiti, Raymond Wakefield, John Parenti.** Rear row: **Alexander Zeumer, Charles Rosengren, Gary Mason, Thomas Steffen, Henry Tap, Thomas Hoogervorst, William Freivald, Thomas Keating, Stanley McIntyre.**

Thomas R. Hoogervorst (right) student at University of Illinois, Navy Pier, Chicago, receives the Chicago Chapter's Robert E. Kennedy Scholarship award from **Rupert M. Price,** assistant dean of engineering, Navy Pier. Watching is **Robert P. Schauss,** Werner G. Smith, Inc., Chicago, and current chairman of Robert E. Kennedy Scholarship Fund Committee. *—N. A. Baranov*

Shown at head table of **Saginaw Valley's** December meeting are Director **George E. Savage,** Buick Motor Div., GMC, Flint, Mich.; Director **W. Arthur Coates,** General Foundry & Mfg. Co., Flint, Mich.; **Kenneth H. Priestley,** Vassar Electroloy Products, Inc., Vassar, Mich.; AFS Technical Director **S. C. Massari;** Chairman **Arthur H. Karpicke,** Central Foundry Div., GMC, Saginaw, Mich.; Vice-Chairman **Ormond Requadt,** Dow Chemical Co., Bay City, Mich.; Secretary **George R. Frye,** Eaton Mfg. Co., Vassar, Mich.; Director **Steve Spess,** Central Foundry Div., GMC, Saginaw, Mich.

Central New York Chapter

Holds First Ladies Night

■ Central New York Chapter held its first combined Ladies Night and Christmas party in November. This was the first time ladies had been invited to chapter activities. The program included dinner, entertainment and dancing. *—C. W. Diehl*

San Antonio Section

Conducts Casting Clinic

■ A general discussion of gating and riserin problems was conducted at the December meeting. K. O. Steel Castings, Inc., and Alamo Iron Works each submitted two problems for study.

Northwestern Pennsylvania Chapter

Using Break-Even Charts

■ Break-even charts, through their ability to illustrate operating conditions at all levels of activity, provide management with information for control of profits not available from other business reports.

Break-even charts are indicative of danger levels during periods of declining business volume or guides for expansion policies during times of increasing activity", R. B. Sinclair, Meehanite Metal Corp., New Rochelle, N.Y., told Northwestern Pennsylvania Chapter Members.

Many other factors can be appraised: determine profit paths at varying levels of production; indicate levels of fixed and variable costs at different sales volumes; and ascertain ratios of fixed to variable costs.

Other uses include:

- Evaluate departmental efficiency.
- Determine required sales levels.
- Index to management efficiency.

—H. L. Buchanan

New England Chapter Chairman **William N. Ohlson** (left), Draper Corp., Hopedale, Mass., and **Loren W. Beebe,** Ingersoll-Rand Co., Boston, shown at November meeting held in Boston.

Wisconsin Chapter

Acid Ladle Practice Talk

■ Thorough control of mixtures and procedures, once established for the particular conditions, was stressed by George DiSylvestro, American Colloid Co., Skokie, Ill., in addressing the Wisconsin Chapter on *Steel Foundry Acid Ladle Practice.*

Also covered were optimum mixtures, ramming and drying procedures for 300-lb to 6-ton ladles on one refractory base material (ganister). The illustrated lecture showed greatly improved ladle life and a reduction of non-metallic inclusions while retaining an economical refractory mix.

Clyde A. Sanders, December speaker at the **Western Michigan Chapter,** discusses problems with Chapter Directors: **R. E. Gilbert,** Great Lakes Founders & Machine Corp., Ludington, Mich.; **B. A. Everlove,** Grand Rapids Casting Co., Grand Rapids, Mich.; and **F. P. Goettman,** Standard Sand Co., Grand Haven, Mich. —*Don Connell*

British Columbia Chapter

Hears Talk on Powder Metallurgy

■ Members of the AFS British Columbia Chapter and the American Society for Metals held a joint meeting in December. Dr. J. A. H. Lund, University of British Columbia discussed *Recent Developments in Powder Metallurgy.* He outlined preparation of powders, compression and sintering and recent investigations being made at the university. —*A. W. Greenius*

Tennessee Chapter at its November meeting heard **Dr. I. W. Grote,** University of Chattanooga, Tenn. (3d from left). Others are: Vice-Chairman **C. E. Seman,** Crane Co., Publicity Chairman **H. G. Nelson,** Crane Co.; and Chairman **W. L. Austin,** U.S. Pipe & Foundry Co. —*H. G. Nelson*

Eastern New York Chapter

Holds Annual Christmas Party

■ Approximately 150 members and guests attended the annual Christmas party. Included were a dinner, entertainment and drawings.

—*L. C. Johnson*

Northern California Chapter

Conducts Casting Clinic

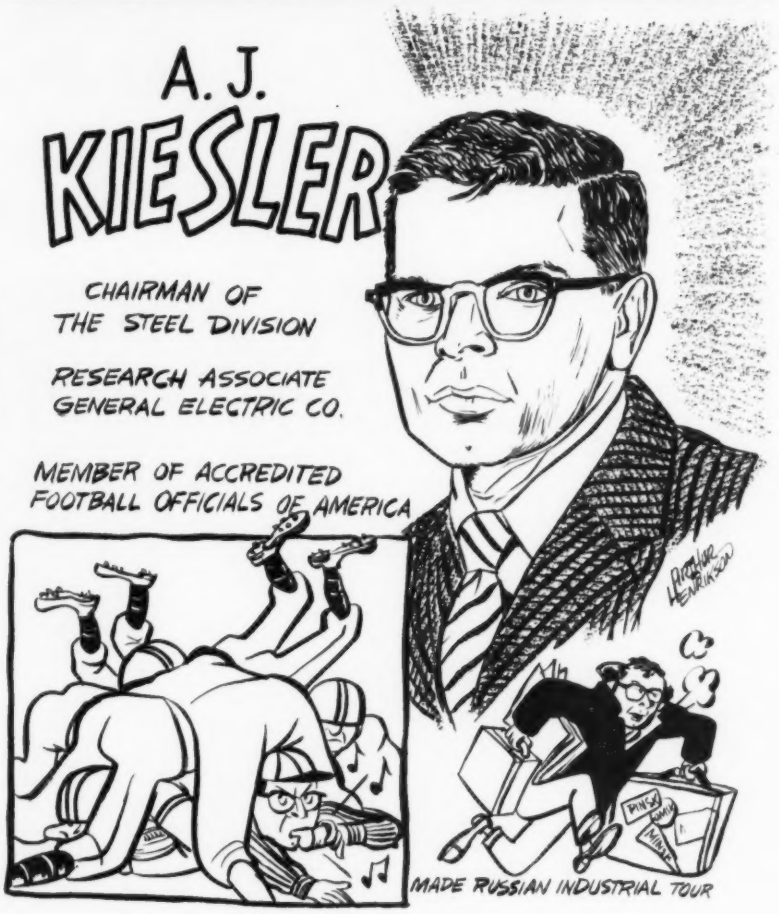
■ Three Bay Area foundrymen led the annual castings clinic featuring discussions on gating and risering. Speakers were Don L. Mason, Superior Electrocast Foundry, South San Francisco, Calif.; Weldon Russell, Phoenix Iron Works Co., Oakland, Calif. and Norman Barnett, M. Greenberg's Sons, San Francisco.

—*E. J. Ritelli*

Students Average 860 Miles

■ Students attending the T&RI *Melting of Copper Base Alloys* course held in Chicago last year averaged 860 miles per round trip. *Metallography of Ferrous Metals,* also held in Chicago, had an average round trip figure of 800 miles. During 1958 the average number of miles per round trip averaged 610 miles per student.

personality



afs chapter meetings

FEBRUARY

Birmingham District . . *See Southeastern Regional Foundry Conference.*

British Columbia . . **Feb. 20** . . Leon's, Vancouver, B.C. . . R. Silva, Fairbanks, Morse & Co., *"Cold-Set Cores."*

Canton District . . **Feb. 5** . . Elks Club, Alliance, Ohio . . H. F. Bishop, Exomet, Inc., *"Gating & Risering."*

Central Illinois . . **Feb. 2** . . Vonachen's Junction, Peoria, Ill. . . R. T. Lewis, Keen Foundry Co., *"Are Your Costs Reliable?"*

Central Indiana . . **Feb. 2** . . Athenaeum, Indianapolis . . C. E. Drury, Central Foundry Div., GMC, *"What's New in Castings Design."*

Central Michigan . . **Feb. 18** . . Hart Hotel, Battle Creek, Mich.

Central New York . . **Feb. 13** . . Drumlins Country Club, Syracuse, N.Y. . . H. J. Weber, AFS, *"Impact of Air Pollution Laws on Foundries."*

Central Ohio . . **Feb. 9** . . Seneca Hotel, Columbus, Ohio.

Chesapeake . . **Feb. 27** . . Engineers' Club, Baltimore, Md. . . A. B. DeRoss, Kaiser Aluminum & Chemical Sales, Inc., *"Aluminum Foundry Practice."*

Chicago . . **Feb. 2** . . Chicago Bar Association, Chicago . . *Gray Iron Group*: M. H. Horton, Material Engineering Div., Deere & Co., *"Operation of Acid & Basic Water-Cooled Cupolas"; Steel & Maintenance Group*: E. J. Prince, Kaiser Industries Corp., *"New Oxygen Converter Process of Steelmaking"; Non-Ferrous Group;* K. A. Miericke, Baroid Div., National Lead Co., *"Oil-Bonded Molding Sands"; Pattern Group*: V. B. Roll, Kish Industries, Inc., *"Plastics for Pattern Equipment."*

Cincinnati District . . **Feb. 9** . . Hamilton, Ohio . . A. A. Evans, International Harvester Co., *"Foundry Quality Control."*

Connecticut . . **Feb. 24** . . Stratfield Hotel, Bridgeport, Conn. . . G. W. Merrefield, Giffels & Vallet, Inc., *"Mechanization in Small Foundries."*

Corn Belt . . **Feb. 6** . . Marchio's Steak House, Omaha, Neb. . . G. O. Pfaff, Wheelabrator Corp., *"Cleaning Room Cost Reduction."*

Detroit . . **Feb. 19** . . Wolverine Hotel, Detroit . . *Ferrous Group*: R. A. Witschey, A. P. Green Fire Brick Co., *"Refractories in Melting Units & Ladles"; Non-Ferrous Group*: R. Rathyen, Joseph Dixon Crucible Co., *"Crucibles — Care for Longer Life."*

Eastern Canada . . **Feb. 13** . . Sheraton Mt. Royal Hotel, Montreal, Que. . . J. E. Rehder, Canada Iron Foundries, Ltd., *"Carbon Injection of Cast Iron."*

Eastern New York . . **Feb. 17** . . Panetta's Restaurant, Menands, N. Y. . . L. W. Songer, General Electric Co., *"Turbine Designs & Their Effect on Casting."*

Metropolitan . . **Feb. 2** . . Essex House, Newark, N. J. . . *Round Table-Aluminum*: D. L. LaVelle, American Smelting & Refining Co.; *Steel*: R. W. Ruddle, Foundry Services, Inc.; *Gray & Nodular Iron*: F. C. Barbour, Republic Steel Corp.; *Brass & Bronze*: R. J. Keeley, Ajax Metal Div., H. Kramer & Co., *"What Foundrymen Should Know About Solidification to Insure Better Castings."*

Mexico . . **Feb. 23** . . Ave. Chapultepec 414, Mexico D.F., Mexico . . M. Chapa, Jr., Fundiciones de Hierro y Acero — S. A., *"Technical Sales of Castings According to Mexican Market Necessities."*

Michiana . . **Feb. 9** . . Club Normandy, Mishawaka, Ind. . . A. H. Homberger, International Automation Corp., *"Buhrer Automated Molding & Pouring Method."*

Mid-South . . **Feb. 13** . . Claridge Hotel, Memphis, Tenn. . . J. A. Mueller, Carborundum Co., *"Save on Snagging & Cut-Off Costs."*

New England . . **Feb. 11** . . University Club, Boston . . D. R. Chester, Archer-Daniels-Midland Co., *"Quality Control in Coreroom."*

Northeastern Ohio . . **Feb. 7** . . Carter Hotel, Cleveland . . *3d Annual Ladies' Night.*

Northern California . . **Feb. 16** . . Spenger's, Berkeley, Calif. . . R. Silva, Fairbanks Morse & Co., *"Cold-Set Cores."*

Northwestern Pennsylvania . . **Feb. 23** . . Amity Inn, Erie, Pa. . . H. L. Smith, Federated Metals, *"Brass & Bronze Melting Practice."*

Ontario . . **Feb. 27** . . Royal Connaught Hotel, Hamilton, Ont. . . *Past Chairmen's Meeting.*

Oregon . . **Feb. 18** . . Heathman Hotel, Portland, Ore. . . R. Silva, Fairbanks Morse & Co., *"Cold-Set Cores."*

Philadelphia . . **Feb. 13** . . Engineers' Club, Philadelphia . . D. J. Henry, General Motors Corp., *"Foundry Needs of Tomorrow's Automobiles."*

Pittsburgh . . **Feb. 16** . . Webster Hall, Pittsburgh, Pa. . . *Non-Ferrous Meeting and Movie of University of Pittsburgh Football Game.*

Quad City . . **Feb. 16** . . LeClaire Hotel, Moline, Ill. . . C. A. Sanders, American Colloid Co., *"Closer Precision with Green Sand Molding."*

Rochester . . **Feb. 9** . . Chamber of Commerce, Rochester, N. Y. . . Dr. W. H. Steiner, General Dynamics Corp., *"Rockets & Space Ships, Their Development Metallurgically." Joint Meeting with American Society for Metals.*

Saginaw Valley . . **Feb. 14** . . Bancroft Hotel, Saginaw, Mich. . . *Annual Ladies' Night Dinner Dance.*

St. Louis District . . **Feb. 12** . . Edmond's, St. Louis . . G. DiSylvestro, American Colloid Co., *"Veining & Penetration."*

Southeastern Regional Foundry Conference . . **Feb. 26-27** . . Hotel Tutwiler, Birmingham, Ala.

Southern California . . **Feb. 13** . . Rodger Young Auditorium, Los Angeles . . L. T. Cuculic, Utility Steel Foundry, *"Shell Cores vs. Other Core Material."*

Tennessee . . **Feb. 20** . . Patten Hotel, Chattanooga, Tenn. . . G. O. Pfaff, Wheelabrator Corp., *"Reducing Blast Cleaning Costs."*

Texas . . **Feb. 20** . . Blackstone Hotel, Tyler, Texas . . G. T. Dupre, National Engineering Co., *"Mechanization for a Small Foundry."*

Texas, San Antonio Section . . **Feb. 16** . . San Antonio Machine & Supply Co., San Antonio, Texas.

Timberline . . **Feb. 9** . . Oxford Hotel, Denver, Colo.

Toledo . . **Feb. 4** . . Heatherdowns Country Club, Toledo, Ohio . . H. E. Gravlin, Chrysler Corp., *"Light Metals vs. Ferrous Metals."*

Tri-State . . **Feb. 13** . . Alvin Plaza Hotel, Tulsa, Okla. . . T. E. Barlow, International Minerals & Chemicals Corp., Eastern Clay Products Dept., *"High Pressure Molding for Copper Base Alloys."*

Twin City . . **Feb. 9** . . Jax Restaurant, Minneapolis . . J. J. Uppgren, Northern Ordnance, Inc., *"The Casting and Welding Industries." Joint Meeting with American Welding Society.*

Utah . . **Feb. 14** . . New House Hotel, Salt Lake City . . *Valentine Party.*

Washington . . **Feb. 18** . . Engineers' Club, Seattle . . R. Silva, Fairbanks Morse & Co., *"Cold-Set Cores."*

Western Michigan . . **Feb. 2** . . Bill Stern's, Muskegon Heights, Mich. . . G. O. Pfaff, Wheelabrator Corp., *"Reducing Blast Cleaning Costs" and Film "Steel Shot."*

Western New York . . **Feb. 6** . . Hotel Sheraton, Buffalo, N.Y. . . W. Illuminati, International Automation Corp., *"New Developments in the Foundry" and Film, "Automated Foundry in Switzerland."*

Wisconsin . . See Wisconsin Regional Foundry Conference.

Wisconsin Regional Foundry Conference . . **Feb. 12-13** . . Hotel Schroeder, Milwaukee.

WEDRON

A COMPLETE LINE OF 24 DIFFERENT PROCESSED SILICA SANDS

A CONTROLLED GRADE FOR EVERY CASTING NEED!

SAND SPECIFICATIONS — REPRESENTATIVE SCREEN ANALYSES

Unground Sand	4098	4085	4060	4040	4030	4020	5040	5030	5025
Ret on 20 Mesh	2.2								
Thru 20 ret on 30	38.6	12.4	5.6	0.6	0.4	0.4			
Thru 30 ret on 40	57.6	70.8	56.2	37.2	30.2	21.2	4.0	1.2	0.6
Thru 40 ret on 50	1.4	16.3	34.8	52.0	55.8	51.4	34.8	30.4	23.8
Thru 50 ret on 70	0.2	0.5	2.8	9.0	11.4	20.6	44.4	48.2	42.0
Thru 70 ret on 100			0.6	1.0	1.8	5.2	14.4	17.8	26.4
Thru 100 ret on 140				0.2	0.4	1.0	2.0	2.0	6.2
Thru 140 ret on 200						0.2	0.4	0.4	0.8
Thru 200 ret on 270									0.2
Grain Fineness (AFS)	25.88	30.49	33.72	37.48	38.82	42.22	49.96	51.64	56.90

Unground Sand	5015	5010	5005	7030	7020	7010	C-30	C-10
Ret on 20 Mesh								
Thru 20 ret on 30								
Thru 30 ret on 40	1.2	0.4	0.2	0.2	0.2			
Thru 40 ret on 50	15.2	11.2	4.4	3.0	2.4	0.4		
Thru 50 ret on 70	40.2	35.2	31.2	26.2	18.0	8.2	0.4	0.2
Thru 70 ret on 100	35.4	37.4	41.2	42.0	45.0	46.6	28.4	8.4
Thru 100 ret on 140	6.4	10.8	15.4	16.4	20.0	23.2	44.8	50.2
Thru 140 ret on 200	1.2	4.0	5.6	9.6	11.0	15.4	18.8	28.2
Thru 200 ret on 270	0.4	0.8	1.4	1.8	2.4	4.2	5.0	8.8
Thru 270 ret on 325		0.2	0.6	0.8	1.0	2.0	2.6	4.2
Grain Fineness (AFS)	60.20	66.92	73.92	79.36	84.42	95.44	108.22	124.60

Ground Sand (Flour)	80M	100M	140M	200M	300M	325M	400M
Ret on 60 Mesh	10/20%						
Thru 60 ret on 100	25/30%	5%					
Thru 100 ret on 140	15/20%	14%	4%	1%			
Thru 140 ret on 200	10/15%	16%	6%	4%	2%	Trace	
Thru 200 mesh	25/40%						
Thru 200 ret on 270		10%	12%	6%	2%	0.5%	Trace
Thru 270 ret on 325		12%	8%	9%	11%	4.5%	2%
Thru 325 mesh		43%	70%	80%	85%	95.0%	98%

99.9% PURE SILICA
WEDRON SILICA COMPANY
INDUSTRIAL SAND

FINE SHELL MOLDING SANDS
STANDARD CASTING SANDS — BLASTING SANDS
SILICA FLOUR — LIGHT METAL CASTING GRADES

Wedron offers you a complete line up of casting sands — anything needed for every *casting* need! This means you get the advantages of one source of supply for all the sand you need — sand of the highest quality, too.

Now this Wedron quality stems from two factors. First is the naturally rounded grain sand of the Ottawa-Wedron district (this is held to be one of the purest silica sand deposits in the nation). Second is the modern, completely equipped Wedron plant, which turns out a superior silica product and makes all grades available.

Look to Wedron for the *complete* line of quality casting sands.

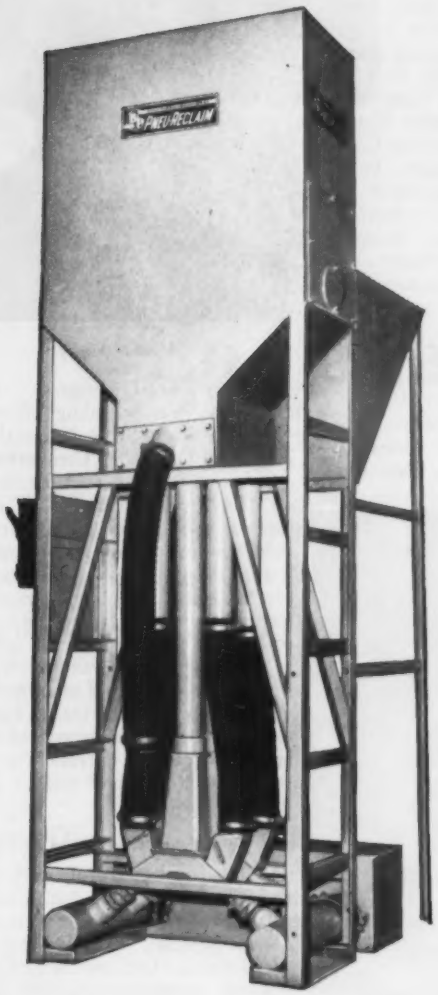
MINES AND MILLS IN THE OTTAWA-WEDRON DISTRICT

WEDRON SILICA COMPANY

135 SOUTH LASALLE STREET, CHICAGO 3, ILLINOIS

Circle No. 500, Page 151-152

IS YOUR FOUNDRY DUMPING OVER $12,000 IN RECLAIMABLE SAND THIS YEAR?



EVEN SMALLER FOUNDRIES DO...

Large expenditures for new sand aren't limited to the larger foundries. Many foundrymen are surprised and even shocked when they calculate the cost of new sand in their foundry operations. One typical medium-size foundry revealed these figures:

Cost of new sand per ton at siding	$5.83
Cost of moving sand to storage, per ton	.65
Cost of storage, per ton	.25
Cost of trucking used sand to dump, per ton	.55
Total cost, per ton	$7.28
Total cost per month (based on 150 tons/month)	$1,092.00

Of course, bigger foundries spend more . . . much more. Yet, the sand hauled to the dump is perfectly reclaimable for use as new sand. The sand dumped represents dollars lost forever . . . dollars that a reclamation unit could save.

NOW—RECLAMATION COSTS LESS

The newest of dry reclamation units—Pneu-Reclaim—actually costs less to install and use than earlier units. Its many exclusive features—dual-jet scrubbing, high recovery fines control, level-flow and simple quantity-quality control—mean lower-cost operation and superior peformance. The typical costs shown below are based on hundreds of actual tests:

Typical cost of reclaiming for reuse in molding sand mixtures, per ton	30c
Typical cost of reclaiming for reuse in core sand mixtures, per ton	90c
Typical cost of reclaiming for reuse in CO_2 sand mixtures, per ton	60c

These costs include all of the charges for power, maintenance and operation. Because Pneu-Reclaim *requires half the air pressure for operation, it consumes half the power required by earlier units.*

AND SAVES MORE!

It's easy to find how much Pneu-Reclaim can save your foundry. Simply compute the actual cost of each ton of sand delivered to your foundry, used in your system and then discarded, and subtract the cost of reclamation. The difference represents the saving offered by Pneu-Reclaim per ton of sand reclaimed and used in lieu of new sand.

TYPICAL EXAMPLE

Cost per ton of sand delivered, used and discarded	$7.28
Cost per ton of sand reclaimed for reuse in molding sand mixtures	.30
Saving per ton	$6.98
Saving per month (based on 150 tons/month)	$1,047.00

A no-obligation demonstration will prove these facts for you. Write today!

B&P PNEU-RECLAIM

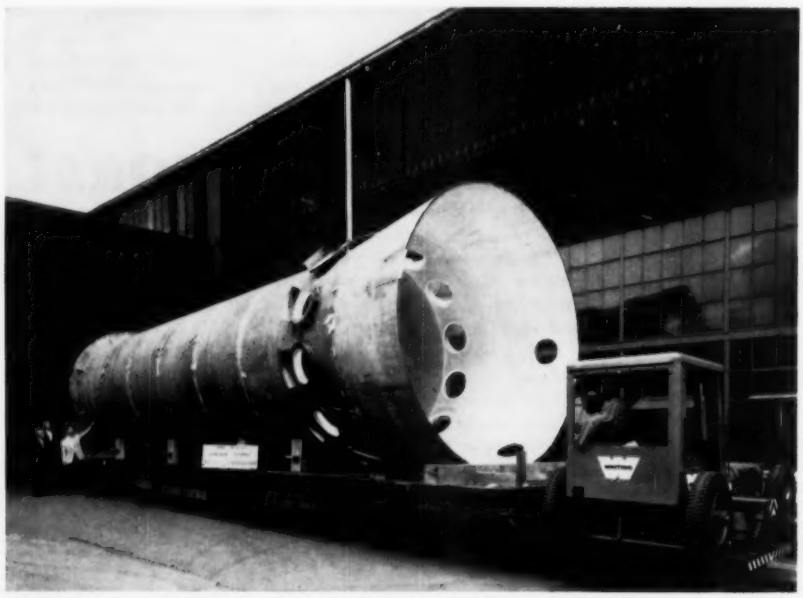
Beardsley & Piper
Div. Pettibone Mulliken Corp.
2424 N. Cicero Ave. • Chicago 39, Illinois

Circle No. 498, Page 151-152

foundry trade news

THE MAGNESIUM ASSOCIATION . . . held its 14th Annual Convention at the Fort Shelby Hotel, Detroit, with the theme Magnesium Looks Ahead. Jerry Singleton, executive secretary stated "the meeting in the Motor City came at a particularly significant time as it is known the automotive industry is now considering manufacture of lightweight, economical cars—possibly as early as the 1960 model year. Magnesium can go far in helping solve many new, as well as old, problems in utilizing lightest of all the structural metals used in American cars and to a larger degree in many of the European autos." Each day was divided into two sessions devoted to discussions and technical papers on manufacturing methods, numerous application studies and economic advantages of using magnesium. Dr. C. J. Smithells, Magnesium Elektron, Ltd., England, spoke at one luncheon meeting on new developments in magnesium applications in Great Britain.

Numerous interesting magnesium applications were displayed showing many of the parts and assemblies providing unique solutions to design problems and are applicable to other types of products. Among the 20 technical papers presented were: *Selection of Optimum Fabricating Methods for Magnesium Components*, C. I. Miller, Martin Co., Baltimore, Md.; *Progress Report on Development of Magnesium Wheels for Automotive Applications*, J. A. Main, Kelsey-Hayes Co., Detroit; *The Where and Why of Magnesium in Automotive Equipment*, E. L. Schaper, and H. A. Schertel, Dow Chemical Co., Midland, Mich.; *Magnesium in the Modern Army Mule*, T. J. Bischoff, Detroit Arsenal, Centerline, Mich.; *Use of Magnesium to Reduce Vibration*, Robert Chater, Detroit Power Coupling Co., Detroit and *Vibration Damping Capacity of Magnesium Alloys*, J. A. Rowland, D. F. Walsh and J. W. Jensen, Branch of Metallurgy, U. S. Bureau of Mines, Region IV, Rolla, Mo.



Whiting Corp., . . . Harvey, Ill., designed this mammoth 50½-ton cupola, said to be the world's largest for installation at Acme Company's new 23-million dollar oxygen converter steel-making plant at Riverdale, Ill. The section shown here dwarfs a group of Acme officials, the tallest being 6 ft 10-in. Morris Jones. Cupola is used to provide hot melt a for low-cost steel making installation which produces steel by blowing pure oxygen over molten pig iron and scrap.

STEEL FOUNDERS' SOCIETY OF AMERICA . . . held the 13th Annual Technical & Operating Conference, Nov. 10-12, Cleveland. The meeting was attended by 476 technical, research and operating personnel of the steel castings industry representing a total of 129 different foundry organizations throughout the United States and Canada. I. M. Emery,

I. M. Emery

Massillon Steel Castings Co., Massillon, Ohio was presiding officer and chairman of the SFSA National Technical and Operating Committee.

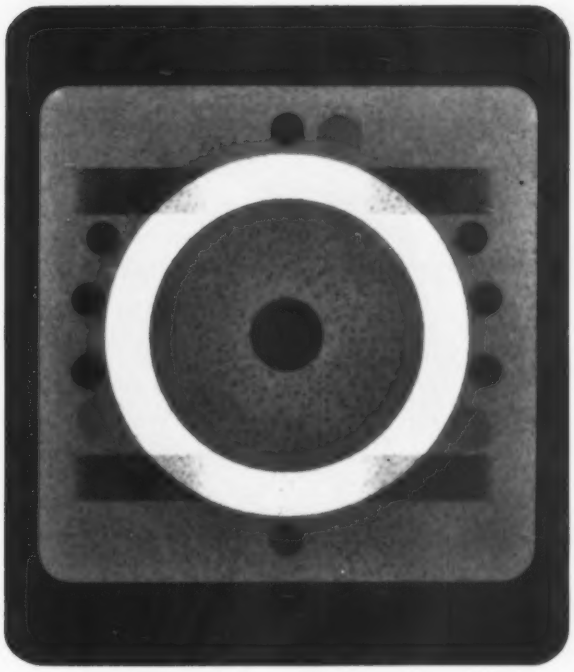
A series of papers were featured on leaded cast steels, metal and refractory mold inserts and recent developments in molding and sand technology. Innovations in steel foundry practice were discussed. A total of 35 lectures presented by 33 authors and co-authors appeared on the three-day program. One day was devoted to a work shop on flow of steel in molds. Papers presented reviewed both the theory and practical aspects of molten metal flow as the operation is understood in the light of today's knowledge of the subject.

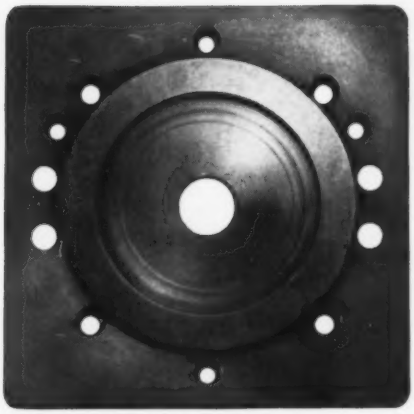
INVESTMENT CASTING INSTITUTE . . . elected Robert R. Miller, Precision Metalsmiths, Inc., Cleveland, as its president during the Institute's annual meeting in New York. John H. Morison, Hitchiner Mfg. Co., was elected vice-president, and K. W. Thompson, K. W. Thompson Tool Co., was elected treasurer.

Elected as directors of ICI were Dr. Jack Keverian, general Electric Co., and D. A. Democh, York Castings, Inc. Directors whose present terms continue for the coming year

Continued on page 132

Radiograph shows porosity which caused markings to be fuzzy





Alloy casting for faceplate of aircraft instrument

End of a fuzzy face

SEE-AT-A-GLANCE clarity is an absolute *"must"* for aircraft instruments. So when one in development appeared with fuzzy numbers and index marks on its face, the cause and cure had to be found.

Sperry Gyroscope Company maintains a large and efficient x-ray testing department, hence the casting for the instrument face was promptly radiographed.

What the radiograph revealed was marked porosity. The conclusion was that the material used in applying the figures was being absorbed and sharp delineation was impossible. Therefore, a change in casting technic was indicated.

This is typical of the ways radiography helps the foundryman make sure only satisfactory work is delivered—make sure he is building and keeping a reputation for high-quality castings. If you would like to know how it can help you, call your x-ray dealer—or the Kodak technical representative—and talk it over.

X-ray Division . . . EASTMAN KODAK COMPANY . . . Rochester 4, N. Y.

Kodak Industrial X-ray Film Type AA

Read what Kodak Industrial X-ray Film, Type AA, does for you:

- Speeds up radiographic examinations.
- Gives high subject contrast, increased detail and easy readability at all energy ranges.
- Provides excellent uniformity.
- Reduces the possibility of pressure desensitization under shop conditions.

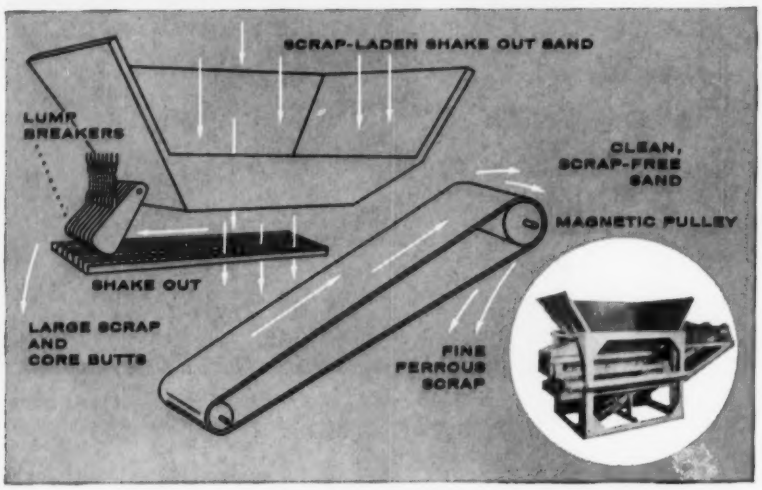
Kodak
TRADE MARK

Circle No. 497, Page 151-152

SAND CONDITIONING TOPICS

PUBLISHED BY ROYER,
MANUFACTURERS OF THE FOREMOST IN SAND CONDITIONING EQUIPMENT

ROYER



Sand Contamination Drains Your Profits

Periodic business recessions in the foundry industry point up the need to eliminate waste and excessive hand labor—or sacrifice profits. In one area of foundry operation—sand contamination — important strides have been made in stopping the profit drainage.

Tramp iron damage usually occurs at the muller, conveyor belts, aerator or patterns. Patterns faced with contaminated sand produce poor casting finishes and high scrap loss. Probably the most efficient and economical way to remove contamination and produce clean sand is with a Royer Scrap Control Unit.

Referring to the drawing, shake out sand from the molding floor is dumped by front-end loader into the receiving hopper. Large scrap is riddled out by the Shake-Out and discharged at convenient wheelbarrow height for collection and removal.

Ferrous scrap small enough to pass through the grid openings of the Shake-Out is separated from the sand by a magnetic pulley at the upper end of the conveyor belt. Depending upon the degree of mechanization you employ, clean sand discharge may be made to a skip hoist feeding a muller, conveyor belt, or into the hopper of a Stationary Royer Separator and Blender for cooling, aeration and blending. We recommend discharge onto a heap for transporting by front-end loader to a Portable Royer Separator and Blender at the molding station for cooling, aerating and fluffing.

If tramp iron is the cause of any of your profit loss, we invite you to discuss your problem with the foundry-wise Royer agent serving your territory. He'll explain how a Royer Scrap Control Unit can pay for itself in less than two years, stop your profit drainage and improve the quality of your castings.

Your first step in stopping profit drainage caused by sand contamination is to mail the coupon for our latest Scrap Control Bulletin. We'll send it without obligation—plus the name of the agent who serves you.

ROYER FOUNDRY & MACHINE CO.

ROYER 155 PRINGLE STREET KINGSTON, PENNA.

Sand Contamination is cutting into our profits. Please rush me your Scrap Control Bulletin.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

Circle No. 501, Page 151-152

Continued from page 130

are: L. R. Schwedes, Lawrence Laboratory; Ted Operhall, Misco Precision Casting Co.; and R. E. Gray, Gray-Syracuse, Inc.

Department of the Navy . . . has announced that all restrictions regarding the conservation of nickel and nickel alloys for Navy engineering applications have been removed.

Ironton Fire Brick Co. . . will place in operation this month at their Ironton, Ohio, plant a modern bulk handling system for raw materials. The new system will include electronic control for the entire weighing and batching system.

Alloys & Chemicals Mfg. Co. . . . Cleveland, announced the addition of chemical fluxes to present line of aluminum and zinc alloys and related chemicals. A complete line of fluxes is being offered to foundries and die casters. Four basic types are being manufactured, namely, cleaning, degassing, permanent mold and grain refiners. Similar fluxes are available to extrusion billet producers.

The Beryllium Corp. . . . Reading, Pa., announced it received a large research and development contract from the Air Force, authorized by the Air Materiel Command, Wright-Paterson Field, Ohio. Contract specifies conducting development of a commercially feasible procedure for producing ductile castings of beryllium metal.

The firm will investigate possibilities of producing castings of this metal by more conventional processes including centrifugal, pressure and vacuum castings techniques. Beryllium is three times stronger than steel on a strength-to-weight ratio basis, its weight being same as magnesium. It retains high strength at temperatures up to 1200 F. Four divisions of the firm participating in the two-year program are: Alloy Div., Reading, Pa.; Precision Castings Div., Exton, Pa.; and Nuclear and Fabrications Divisions, Hazelton, Pa.

Honolulu Iron Works Co. . . . Honolulu, Hawaii, has become a licensee of Sorbo-Mat Process Engineers, St. Louis, and will manufacture Sorbo-Mat controlled specification cast metals in their foundries. Rearrangement and expansion of facilities are being made in accordance with a program recommended by Foundry Design Co., St. Louis.

Continued on page 136

CARBO-SIL® No. 4*

The Only Low-cost and Consistent Method of Adding Silicon Carbide in Your Cupola

A positive silicon source that:

- * Cuts Costs
- * Increases Machinability
- * Improves Fluidity
- * Controls Chill

CARBO-SIL No. 4, a silicon carbide addition for cast iron cupolas, comes in 10 and 15-pound units encased in steel containers.

BECAUSE CARBO-SIL No. 4 comes in steel containers, every crystal of the pre-crushed silicon carbide is *fully* protected until it reaches the significant melting zone of the cupola. Then it *completely* reacts and goes into solution.

CARBO-SIL No. 4 is competitively priced with silicon carbide in briquette form. You save money because there's no waste. If briquettes are made sturdy, they only partially dissolve and often are found in the drop. If made fragile, they break up prematurely and are partially blown out the stack.

There are 4½ pounds of available silicon (as silicon carbide) in the 10-pound unit and 6¾ pounds in the 15-pound unit. Each container adds almost a pound of steel to your charge at no extra cost.

Write for details.

Safe Outdoor Storage

CARBO-SIL No. 4 is packed in palletized, waterproofed and top-strapped units for space-saving outdoor storage.

AMMET

AMERICAN METALLURGICAL PRODUCTS COMPANY

3600 FORBES AVENUE / PITTSBURGH 13, PA. / PHONE MUSEUM 2-7031

Circle No. 502, Page 151-152

MEASURE
HEAT
ACCURATELY
with

the improved

PYRO OPTICAL PYROMETER

The only self-contained direct-reading optical pyrometer for quick temperature measurements of molten iron, steel, monel, etc.

Send for catalog No. 85.

the universal

PYRO SURFACE PYROMETER

Rugged, easy to read. Ideal for shell molding, core oven, mold and die surface temperature measurements. Single and double ranges from 0-300°F to 0-1500°F.

Send for catalog No. 168.

PYROMETER INSTRUMENT CO., INC.
BERGENFIELD 10, NEW JERSEY

Circle No. 503, Page 151-152

Why Use Shell Cores?

EARL W. JAHN / *President*
Production Pattern & Foundry Co.
Chicopee, Mass.

Why did we make shell *molds* before shell cores and why have we only been making shell cores in production for about 3 years? We needed coated sand. Segregation occurs when blowing a core in dry blend. We had to "creep" with dry blend before "walking" with coated sand. In talking about shell cores, you must keep in mind that we are comparing shell cores with other types of core.

One of the expensive core-making operations is material handling. Where it's possible to use a shell core, the core is usually lighter. In making a lighter core, you're handling less material. It is not uncommon to make a hollow shell core that weighs 50 per cent less than another type of solid core. The cost of oil sand cores is approximately one cent per pound for material. The cost of shell cores is approximately two cents per pound for material. However, when a shell core is 50 per cent lighter than an oil sand core, the net material cost is the same.

WHY USE A SHELL CORE? It has to result in an over-all *cost saving* or it should not be used. Some of the advantages of shell cores are:

1. *SHELL CORE ACCURACY.* The core is made in the corebox, cured and hardened in the corebox, and every core comes the same size. Core sag is eliminated making it unnecessary to grind cores. Finning is eliminated, greatly reducing the amount of grinding of castings in the cleaning room.

2. *LESS GAS.* Making a hollow shell core rather than a solid core, you use less gassy material and, therefore, generate less gas from the core than in other types of material. When a core is hollow, no core vents are required.

3. *CORE DRIERS.* Driers are completely eliminated in shell cores. Driers are costly things:—to make, to store, and to handle—to and from, back and forth.

4. *DENSITY AND SMOOTHNESS.* Because shell gives a clean smooth core dirt or dust is readily blown off. Absence of moisture leads to greater flowability of the sand, allowing intricate cores to be blown denser and making a smoother casting. Smoother internal walls on castings produce a better, more efficiently operating finished product. Need for core wash is also eliminated.

5. *OVEN CAPACITY.* In ordinary times, very few foundries have ample oven capacity or floor space. In making shell cores, each operator has his own oven. He can be located nearer the molding line, thereby cutting down farther on material handling.

6. *STRENGTH.* A shell core made with a four-percent resin mix is stronger than a conventional core of normal mix. In our foundry we have less than a fraction of one per cent breakage due to handling of shell cores. For conventional cores, the breakage percentage is two to three per cent.

7. *CORE PLATES ELIMINATED.* This is an ever-mounting cost. At one check, we found that in our foundry we had $54,000 worth of aluminum-core plates and never enough of them. Again, back and forth, heat and reheat, plates that we will never sell.

8. *LESS HEAT REQUIRED TO BAKE A LIGHTER CORE.* It takes 88 btu to heat one pound of silica sand to 450F. If less sand is used to produce a shell core, it will require less btu. You do not heat core racks, driers or core plates.

9. *VENTING COREBOXES.* Very little if any venting is required because of flowability, absence of moisture, lower blow pressures.

10. *MIX SHELL CORE SAND WEEKS AHEAD.* Other core sands that have not been used have to be re-mixed or disposed of, especially over weekends.

■ In one year, we have produced approximately 2,000,000 shell cores. These cores weighed from less than 1 oz to 12 lb. We have, or are putting all our high production cores into shell cores.

Circle No. 504, Page 151-152

A Salute to the Men of the Great Foundry Industry...

THE Foundry Industry is one of America's great industries. Over 90% of all durable goods require metal castings.

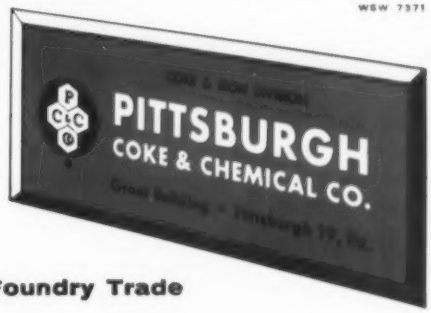
Today's gray iron industry is essentially a *craft* industry. The quality of its products depends upon the skill of its craftsmen.

This is especially true in the case of the *Pattern Maker*. For his skill in creating patterns to exact blueprint specifications is reflected in the quality of every gray iron casting produced.

Pittsburgh Coke & Chemical Company is proud to salute the gray iron foundry Pattern Maker. It is equally proud to serve as a basic supplier of two quality products for the nation's foundry trade . . . Neville Pig Iron and Neville Foundry Coke.

An enlarged (11¼" x 12") reproduction of the above etching, and of subsequent ads of this series, suitable for framing, will be sent without cost upon request.

WSW 7371



Neville Pig Iron and Neville Coke for the Foundry Trade

PIG IRON • COKE • FERROMANGANESE • CEMENT • COAL CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON

Circle No. 505, Page 151-152

Haul Castings the Economical Sterling Way!

These all-steel, heavy duty trucks come in handy for hauling castings to and from cleaning room. With roller bearing wheels and ball bearing swivel casters, they glide along smoothly, maneuver easily. Save both time and labor. Capacity 2,000 lbs. Sturdy, reinforced welded construction. Write for literature.

STERLING NATIONAL INDUSTRIES, Inc., Milwaukee 14, Wis., U. S. A.
Founded 1904 as Sterling Wheelbarrow Company

Sterling
FOUNDRY EQUIPMENT

Circle No. 506, Page 151-152

Keep your file up to date on the newest high-performance, cost-reducing foundry refractories. Breaker cores, strainer cores, gate tiles —the entire line of Louthan's popular gating and risering refractories.

Write for one or more free file copies today.

THE Louthan MANUFACTURING COMPANY
A DIVISION OF FERRO CORPORATION
EAST LIVERPOOL, OHIO

Circle No. 476, Page 151-152

foundry trade news

Continued from page 132

Miller Manufacturing Co. . . . Detroit, purchased Crawford Steel Foundry Co., Bucyrus, Ohio. Crawford employs about 150 people and makes carbon and low-alloy castings. The firm will continue to operate as a subsidiary.

Grimm Foundry Co. . . gray iron foundry at Bound Brook, N.J., has closed. The operation was one of the oldest foundries in the state.

Mexico Refractories Co. . . . board of directors authorized construction of a $2,000,000 refractories plant near Stockton, Cal. The Mexico, Mo., plant will also be modernized and completed by the end of this year. The new Stockton plant, with deposits of high grade refractory clays and sand sufficient for many years supply, will be the sixth manufacturing plant in Mexico Refractories system, for manufacture of fireclay and silica brick and refractory mortar, plastic firebrick and insulating materials.

Fullerton Pattern Shop . . . Vancouver, B. C., Canada, has been opened by J. S. Fullerton and will supply patterns, for the foundry trade.

Wayne American Co., and **C. H. Wheeler Mfg. Co.** . . . both of Philadelphia, jointly announced acquisition of Carver Foundry, Inc., stock. Ownership will be equally divided between the firms and Carver will operate separately under their joint supervision. The firm is capable of making gray iron castings up to 4000 lb and non-ferrous castings to 2000 lb.

Canton Pattern & Foundry Co. . . . Canton, Ohio, is new name of Canton Pattern & Mfg. Co., according to L. C. Dubbs, president. It will continue to manufacture same line of gray iron and semi-steel castings, and a wide line of alloy-iron products for general industrial use.

International Automation Corp. . . . Ann Arbor, Mich., is the new name of American Automation Corp. Their location is the same and no changes in operations have been made.

National Malleable & Steel Castings Co. . . . reported the recall of 130 workers at its Cleveland plant. Company officials stated the demand for malleable and steel castings for use in agricultural and earthmoving equipment produced the increased business which allowed the recall of furloughed workers.

Beach wear by Jantzen

PAY ONLY $155.00 PER TON

for "SEMI-STEEL"

AND GET CLEANING PERFORMANCE CLOSELY APPROXIMATING THAT OF STEEL ABRASIVES

"SEMI-STEEL" is an entirely new abrasive developed by METAL BLAST. It has marked steel abrasive characteristics and is produced so efficiently that it can be sold at an extremely low price. Its performance compares so favorably with that of steel abrasive, that — because you save upwards of $50 per ton, you can't help but cut cleaning costs. You'll save on maintenance costs, too! And — METAL BLAST will guarantee it — in writing! Here's a sure way to cut production costs — why not investigate?

FREE ENGINEERING SERVICE....

METAL BLAST's field engineer, fully experienced in both abrasives and equipment, is ready to help solve your cleaning problems. Let us know if he can be of assistance. Our testing lab is at your disposal, too. Write or phone for information on our Free Lab Test.

METAL BLAST, INC.

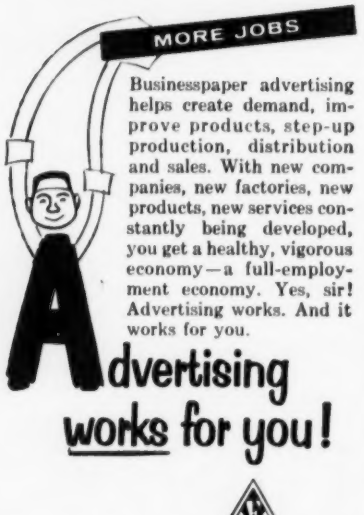
872 EAST 67th STREET • CLEVELAND 3, OHIO
Phone: EXpress 1-4274

"SEMI-STEEL" IS MANUFACTURED AS SHOT AND GRIT TO S.A.E. SPECIFICATIONS. 50 OR 100 LB. BAGS, PALLETIZED IF DESIRED.

Circle No. 507, Page 151-152

BETTER PRODUCTS
Businesspaper advertising brings you information on new and better products, alerts you to new processes and production methods by which you can improve your own products. That's why it pays to read the advertising in your businesspaper. Helps you keep an ear to the ground for new and important developments you can put to work—profitably.
Advertising works for you!

LOWER PRICES
Businesspaper advertising helps to lower prices of the products you buy and sell by broadening markets, building sales volume, bringing you cost-saving opportunities. When you're looking for ways to lower costs and prices . . . give better value . . . and improve profits, it's the editorial pages of your businesspapers that tell you *how*—and the advertising pages that tell you *with what*.
Advertising works for you!


MORE JOBS
Businesspaper advertising helps create demand, improve products, step-up production, distribution and sales. With new companies, new factories, new products, new services constantly being developed, you get a healthy, vigorous economy—a full-employment economy. Yes, sir! Advertising works. And it works for you.
Advertising works for you!

Advertising Federation of America
Advertising Association of the West

Prepared for AFA and AAW by the Associated Business Publications in the interest of better understanding of businesspaper advertising.

Circle No. 504, Page 151-152

let's get personal

Continued from page 22

George Vingas . . . has been appointed research director for Wehr Steel Co., Milwaukee. He is the chairman of AFS Committee 8-H.

Harrison Taylor . . . became manager of the New York district office of Whiting Corp., Harvey, Ill. succeeding **F. P. Walsh,** who retired.

R. W. Jordan . . . has been elected vice president, Hamilton Foundry & Machine Co., Hamilton, Ohio. Jordan is a member, AFS Cincinnati Chapter.

J. P. Maddox . . . will fill the newly created post of manager of market research and development for Mexico Refractories Co., Mexico, Mo.

Jim Mosely . . . has recently completed two years under Charles Briggs with Steel Foundry Society in Cleveland and is now, director of quality control, Atlas Steel Castings Co., Buffalo, N.Y.

obituaries

V. E. Minich, 91, founder of Wheelabrator Corp., Mishawaka, Ind., and honorary chairman of the board, died Dec. 13. He established the American Foundry Equipment Co. in 1910, with headquarters in Cleveland. In 1926, headquarters and plant of the

V. E. Minich

firm were moved to Mishawaka. Later, with introduction of airless abrasive blast cleaning units, the name of the company was changed to American Wheelabrator & Equipment Corp., and then in 1955, to Wheelabrator Corp.

Minich was the first president, Foundry Equipment Manufacturers' Association, serving from 1919 to 1921. He was also a national director for AFS, 1916-1924.

B. O. Collins, vice-president, A. H. Putnam Co., Rock Island, Ill., died recently. He was a member, AFS Quad City Chapter.

L. A. Bonner, district sales manager, American Smelting & Refining Co., Philadelphia, died recently. He was a member, Philadelphia Chapter.

G. E. Hochgesang, foundry consultant, International Nickel Co., Hackettstown, N. J., died recently. He was a member, AFS Metropolitan Chapter.

R. C. Britton, 71, president and treasurer, Urick Foundry, Erie, Pa., died Dec. 6. He took over joint leader-

R. C. Britton

ship of the company in 1937. Britton served as the first treasurer, AFS Northwestern Pennsylvania Chapter in 1945, and was currently a member of the chapter.

David Evans, 84, founder and former chairman of the board, Chicago Steel Foundry Co., Chicago, died Dec. 24. He founded the company in 1906 and retired as chairman in 1954. Evans was named an AFS national director in 1935 and was a member, AFS Chicago Chapter.

H. W. Titgen, 71, retired executive vice-president of the former J. W. Paxson Co., Philadelphia, died Dec. 18. He was considered an expert in building cupolas, blasting equipment and dust collectors; and was patentee of the Boot-Leg Cupola Tuyere which has long been in general use.

W. E. Fowler, Jr., 78, sales manager Metallurgical Div., Barium & Chemicals, Inc., Willoughby, Ohio, died Nov. 29. He had been associated with the company for 20 years, and was a member, AFS Pittsburgh Chapter.

W. A. Zeis, president, Walter A. Zeis Foundry Supply & Equipment Co., Webster Groves, Mo., died Dec. 13. He was current assistant membership chairman, AFS St. Louis Chapter.

Comes out better with

KOPPERS *Premium Foundry Coke*

You'll have fewer rejects—far better quality castings when you switch to Koppers Premium Foundry Coke. Car after car, Koppers delivers a superior coke that's absolutely *uniform* in *size, strength, structure* and *chemical analysis.* Because of the higher carbon content in Koppers Premium Foundry Coke, the foundryman can maintain a higher temperature range which increases the cleanliness of the iron. This in turn, helps reduce fuel consumption—means lower operating costs all around. Next time order Koppers Premium Foundry Coke. Available anywhere in the U.S. or Canada in sizes to meet your needs. Koppers Company, Inc., Pittsburgh, Pa.

WE CHECK EACH DAY'S RUN to make certain you get foundry coke of the exact size and chemistry that is most efficient for the job. Analyses are available to your foundry on request.

Circle No. 508, Page 151-152

Build an idea-file for improvement and profit. The post-free cards on *the last page* will bring more information . . .

for the asking

CO_2 process . . . handbook illustrates equipment and describes process, 46 pp. *Carver Foundry Products Co.*
Circle No. 341, Page 151-152

Cost control . . . pointers are listed and discussed in bulletin. *Small Business Administration.*
Circle No. 342, Page 151-152

Metalcasting technology . . . experts have written many books and manuals which are available through AFS. A complete, classified list is yours when you use the circle number below. *American Foundrymen's Society.*
Circle No. 343, Page 151-152

Silica sand . . . brochure offers pictorial tour of mining to shipping operation. Also chemical analysis and fineness grades listed. *Wedron Silica Co.*
Circle No. 344, Page 151-152

Non-ferrous scrap metals . . . standard classification circular contains standards effective Aug. 1, 1958. *National Association of Waste Material Dealers, Inc.*
Circle No. 345, Page 151-152

Shell molding . . . with forsterite grains described in 4-p brochure. *Harbison-Walker Refractories Co.*
Circle No. 346, Page 151-152

Tape recordings . . . of technical talks on many facets of the metalcastings industry are available from AFS. Circle number below for complete listing. *American Foundrymen's Society.*
Circle No. 347, Page 151-152

Drafting standards . . . for microfilmed engineering drawings, for report use circle number below. *Filmsort Co.*
Circle No. 348, Page 151-152

Clamping tools . . . catalog acquaints reader with application, construction, specification and price data on over 400 items. *Wilton Tool Mfg. Co.*
Circle No. 349, Page 151-152

Metal-ceramics . . . for use in high-temperature operations where most metals or ceramics alone are insufficient, officials state; 12-p brochure. *Haynes Stellite Co.*
Circle No. 350, Page 151-152

Locate conveyor troubles . . . with handy pocket-sized slide card affording methods for pinpointing trouble and listing cures. *United States Rubber Co.*
Circle No. 351, Page 151-152

Investment casting . . . process fully explained in 2-p brochure. *Alloy Steel Casting Co.*
Circle No. 352, Page 151-152

Plastic steel . . . bulletin offers complete coverage on its chemical and physical properties, and case histories of its application. *Devcon Corp.*
Circle No. 353, Page 151-152

Western bentonite . . . brochure presents advantages and explains differences between various types and grades. *Archer-Daniels-Midland Co., Federal Foundry Supply Div.*
Circle No. 354, Page 151-152

he's a hero!
he told the boss about all the info you can get by circling the numbers on the card, last page of this issue

Precision castings . . . used in manufacture of radar wave guides is the subject of **tear sheet** available for the asking. Feature article was published in Modern Castings. *American Foundrymen's Society.*
Circle No. 355, Page 151-152

Current-proportioning . . . instrument is new addition to company's line of millivoltmeters. Use number below for thorough description. *Minneapolis-Honeywell Regulator Co.*
Circle No. 356, Page 151-152

Steel shelving . . . installed without bolts discussed in 8-p brochure. *Penco Div., Alan Wood Steel Co.*
Circle No. 357, Page 151-152

Foundry flasks . . . which reportedly offer easy removal from molds covered in bulletin listing specifications. *Hines Flask Co.*
Circle No. 358, Page 151-152

Pallet handling . . . equipment for maneuvering in small aisles well-illustrated and detailed in 24-p booklet. *Raymond Corp.*
Circle No. 359, Page 151-152

Precision finishing . . . by wet blasting methods discussed in company magazine. *Techline Div., Wheelabrator Corp.*
Circle No. 360, Page 151-152

Hints on handling . . . piling, lifting of materials offered in pamphlet. Includes rules for driving power trucks. *National Safety Council.*
Circle No. 361, Page 151-152

Use of oxygen . . . and other gases in metallurgical processes such as flushing molten metals and use in malleable air furnaces included in series of six reports available. *National Cylinder Gas Div., Chemetron Corp.*
Circle No. 362, Page 151-152

Stress analysis . . . by new technique is throughly detailed in brochure. *Tatnall Measuring Systems Co. and Krouse Testing Machine Co.*
Circle No. 363, Page 151-152

Case histories . . . of use of company's cranes, trambeam handling systems and processing equipment shown in brochure. *Whiting Corp.*
Circle No. 364, Page 151-152

Drying feeder . . . designed to provide efficient drying of material while moving on vibrating conveyor. Explained on data sheet. *Syntron Co.*
Circle No. 365, Page 151-152

Radical saw . . . Use described in catalog. Forty-two different uses. *Delta Power Tool Div., Rockwell Mfg. Co.*
Circle No. 366, Page 151-152

Storage racks . . . expandable, presented in brochure. *Jarke Mfg. Co.*
Circle No. 367, Page 151-152

Rollover draw . . . and jolt rollover draw machines described in 8-p brochure. *Beardsley & Piper.*
Circle No. 368, Page 151-152

Centrifugal casting . . . process fully explained and illustrated in 8-p booklet. *Centrifugal Casting Co.*
Circle No. 369, Page 151-152

Storage racks . . . designed for economy in warehousing illustrated in 4-p folder. *Palmer-Shile Co.*
Circle No. 370, Page 151-152

Portable heating . . . blower heaters and infra-red heaters described in brochure. *Insto-gas Corp.*
Circle No. 371, Page 151-152

Iron foundry alloys . . . covered in brochure detailing composition, uses and advantages of 31 alloys. *Vanadium Corp. of America.*
Circle No. 372, Page 151-152

Precision finishing . . . by vibrating action reportedly works 10 to 100 times faster than tumbling. Use circle number for brochure. *Lord Chemical Corp.*
Circle No. 373, Page 151-152

Continued on page 142

Accepted by foundrymen all over the world as an alloy they can use when they really need reliable help, Molybdenum answers all demands.

Alloys of Molybdenum, dissolving rapidly at normal steel or iron melting temperatures are available and their use is widespread.

Your customers feel comfortable when they know MCA "moly" is in their castings. Casting salesmen are satisfied their customers will have full confidence in Molybdenum iron or steel.

Foundrymen's full knowledge of how to handle Molybdenum makes for a maximum performance. All of this adds up to Molybdenum in your iron and steel castings as positive assurance of expected performance.

As recognized authorities in the application of Molybdenum, Tungsten, Boron, Rare Earths, Columbium, and the alloys and chemical elements of these materials, MCA assures confidential and immediate response to inquiries.

MOLYBDENUM

Grant Building CORPORATION OF AMERICA **Pittsburgh 19, Pa.**

Offices: Pittsburgh, Chicago, Los Angeles, New York, San Francisco
Sales Representatives: Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland-Tungsten, Inc., Cleveland
Plants: Washington, Pa., York, Pa.

MCA

Circle No. 509, Page 151-152

KNOW HOW

PQ

SODIUM SILICATES CAN SERVE YOU?

This bulletin puts valuable facts about sodium and potassium silicates at your finger tips. It reviews the physical and chemical properties of PQ Silicates that are useful in various industrial processes.

Uses for sodium silicates which may have special interest for you . . . sealants for porous castings • binders for cements, foundry molds • detergents for cleaning metals • coagulant aids in water treatment.

Mailed free by request on your business letterhead.

PHILADELPHIA QUARTZ COMPANY

1125 Public Ledger Bldg., Philadelphia 6, Pa.

TRADEMARKS REG. U.S. PAT. OFF.

PQ SOLUBLE SILICATES

Associates: *Philadelphia Quartz Co. of Calif. Berkeley & Los Angeles, Calif.; Tacoma, Wash.; National Silicates Limited, Toronto, Canada*

PQ PLANTS: ANDERSON, IND.; BALTIMORE, MD.; BUFFALO, N.Y.; CHESTER, PA.; JEFFERSONVILLE, IND.; KANSAS CITY, KANSAS; RAHWAY, N.J.; ST. LOUIS, MO.; UTICA, ILL.

Circle No. 510, Page 151-152

for the asking

Continued from page 140

Operator-led . . . industrial trucks bulletin helps reader to determine truck best suited for particular job. *Automatic Transportation Co.*
Circle No. 415, Page 151-152

Electric cleaning . . . equipment for blowing, vacuuming, spraying and air-sweeping applications – hand portable cleaners. *Ace-Sycamore, Inc.*
Circle No. 374, Page 151-152

Air filter . . . for compressed air systems completely detailed in brochure. *Perfecting Service Co.*
Circle No. 375, Page 151-152

Pipeline aftercoolers . . . for industrial air compressor service are well illustrated in booklet complete with specifications. *American-Standard Products, Ross Heat Exchanger Div.*
Circle No. 376, Page 151-152

Tramrail engineering . . . booklet details studies of track design, peening and stresses. *Cleveland Crane and Engineering Co.*
Circle No. 377, Page 151-152

Fireclay brick . . . discussed in bulletin No. 1, plus high temperature mortars, plastics, castables and insulating materials. *Frazee Fire Brick & Materials, Inc.*
Circle No. 378, Page 151-152

Index . . . to 1957 MODERN CASTINGS with cross references by subject, title and author available. *American Foundrymen's Society.*
Circle No. 379, Page 151-152

Foamed silica . . . material for insulating and refractory applications presented in folder. *Pittsburgh Corning Corp.*
Circle No. 380, Page 151-152

Core blowing . . . and mold blowing machines as well as sand mixer and core drawing machines have been added to company's line. Request bulletin for full details. *Beardsley & Piper, Div. Pettibone Mulliken Corp.*
Circle No. 381, Page 151-152

Recording and controlling . . . instruments discussed with applications shown in 4-p brochure. *Barber-Colman Co.*
Circle No. 382, Page 151-152

Inspection cost . . . control in small plants is subject of government bulletin. *Small Business Administration.*
Circle No. 383, Page 151-152

Fork truck report . . . details how cores are moved on pallets from ovens to finishing to storage. *Clark Equipment Co.*
Circle No. 384, Page 151-152

Training courses . . . pertinent to every type of metalcasting work are offered by the AFS Training and Research Institute. For free brochure covering all courses offered, circle number below on Reader Service card, last page. *American Foundrymen's Society.*
Circle No. 385, Page 151-152

Super-pure chromium . . . properties explained on data sheet. *Chromalloy Corp.*
Circle No. 386, Page 151-152

Flexible shafts . . . and flexible shaft machines listed in catalog. *Stow Mfg. Co.*
Circle No. 387, Page 151-152

Nickel-base alloy . . . reportedly offers good resistance to corrosion from sulphuric acid. Use circle number to request bulletin. *Haynes Stellite Co.*
Circle No. 388, Page 151-152

Heavy-duty crane . . . designed to handle big jobs at low cost covered in booklet available when you circle number below on Reader Service card, last page. *Whiting Corp.*
Circle No. 389, Page 151-152

Material handling . . . basic concepts are outlined in revised publication, 16 pp. *Material Handling Institute, Inc., Educational Div.*
Circle No. 390, Page 151-152

Investment casting . . . process said to produce parts in most castable metals and alloys up to 50,000 per day. Request bulletin. *Casting Engineers, Inc.*
Circle No. 391, Page 151-152

how to get a man out of the sand and much other valuable information is yours each month as a subscriber to **modern castings**

Oscillating conveyors . . . reportedly most complete line available to industry, covered in 24-p book. *Link-Belt Co.*
Circle No. 392, Page 151-152

Sling chains . . . completely revised catalog of entire line. *McKay Co.*
Circle No. 393, Page 151-152

Grinding wheel . . . safety recommendations offered in 24-p booklet. *Grinding Wheel Institute.*
Circle No. 394, Page 151-152

Conveyor-belt width . . . is quickly determined, proper width for the job, by using nomograph available for the asking. *Sandvik Steel Belt Conveyors, Div. Sandvik Steel, Inc.*
Circle No. 395, Page 151-152

Pneumatic conveying . . . systems shown in 10-p brochure pointing out advantages and savings of this type conveying. *Day Sales Co.*
Circle No. 396, Page 151-152

Ductile iron . . . is subject of **free reprint** of feature article which appeared in MODERN CASTINGS. Roundup of technology and properties. *Ohio Ferro-*

Continued on page 144

CUT

Crucible Costs

by using the right crucible for the job

Why use a crucible that far exceeds temperature requirements... at five times the cost... when you can buy DFC's time proven crucibles to do your ***exact*** job?

For risering, pouring, spouting and gating, high precision investment casting, lost wax process and permanent mold work... DFC low cost crucibles are adaptable to almost all types of metal.

Refractories stamped DFC have 83 years of blending and firing know-how behind them. Their quality, serviceability, accuracy and minimum pick-up surfacing, are known world wide.

So take a long look at ***your*** crucible costs ***today*** and you'll find Denver Fire Clay will save you money. Write for full information regarding ***your*** crucible situation.

Please send full information on Crucibles; _____Investment Casting, _____Lost Wax Casting, _____Permanent Mold Casting, or other metallurgical clay goods_____

Name.....

Title.....

Firm.....

Address.....

DFB-2

DFC

THE DENVER FIRE CLAY COMPANY

3033 BLAKE STREET DENVER, COLORADO

DENVER • SALT LAKE CITY • EL PASO

Circle No. 511, Page 151-152

for the asking

Continued from page 142

Alloys Corp.; American Foundrymen's Society.
Circle No. 397, Page 151-152

Foundry refractories . . . breaker cores, strainer cores, gate tiles—complete line of gating and risering refractories offered in brochure. *Louthan Mfg. Co., Div., Ferro Corp.*
Circle No. 398, Page 151-152

Electric furnaces . . . and ovens illustrated on data sheet. *L&L Mfg. Co.*
Circle No. 399, Page 151-152

Anchor steel plates . . . for industrial floors illustrated as to construction and use. *Stelcon Industrial Floors, Inc.*
Circle No. 400, Page 151-152

Briquettes . . . for improved microstructure and machinability of gray iron detailed in 14-p brochure featuring many photomicrographs. *Electro Minerals Div., Carborundum Co.*
Circle No. 401, Page 151-152

V-belt drives . . . selection and installation detailed in brochure. *B. F. Goodrich.*
Circle No. 402, Page 151-152

Slotted angles . . . steel framing material presented with specifications and illustrated uses in brochure. *FlexAngle Corp.*
Circle No. 403, Page 151-152

Index . . . to 1958 MODERN CASTINGS. Lists the subjects, titles and the authors of all important information published during last year. *American Foundrymen's Society.*
Circle No. 404, Page 151-152

training films

■ **The following list of motion pictures and film strips will prove useful in educating your personnel to better perform their jobs. Circle the appropriate number on the Reader Service card (page 7-8) for complete information regarding these films. Items indicate whether films are available free of charge, by rental or by purchase only.**

High Energy Radiations for Mankind . . . devoted to applications of machine-produced radiation. Color, 16 mm, sound, 17 min, free. *High Voltage Engineering Corp.*
Circle No. 405, Page 151-152

Shop Safety . . . illustrates accidents, their causes and prevention. Sound, black and white, 16 mm, 28 min, rental. *United World Films.*
Circle No. 406, Page 151-152

How to Weld Aluminum—Arc Welding . . . illustrates metal arc, carbon arc, and atomic hydrogen processes. Sound, black and white, 16 mm, 10 min, free. *U. S. Bureau of Mines Experiment Station.*
Circle No. 407, Page 151-152

Ferroalloys . . . and other metals for iron and steel foundries; their compositions and uses detailed in brochure. *Vanadium Corp. of America.*
Circle No. 408, Page 151-152

Chain slings . . . and assemblies employing new coupling link discussed in bulletin. *McKay Co.*
Circle No. 409, Page 151-152

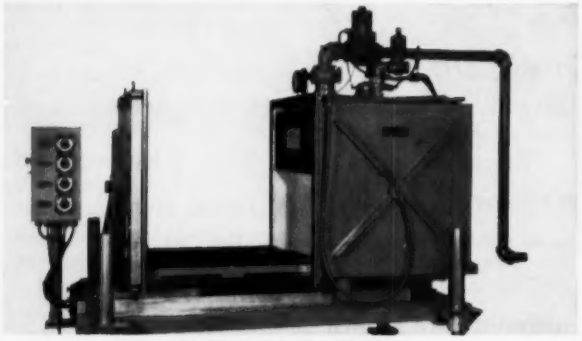
Ferromanganese-silicon . . . saves manganese costs for stainless steel. Bulletin explains slag reactions. *Electro Metallurgical Co.*
Circle No. 410, Page 151-152

Lubricating . . . equipment, fittings and accessories for complete automation or modernization films, listed in 32-p catalog. *Lincoln Engineering Co.*
Circle No. 411, Page 151-152

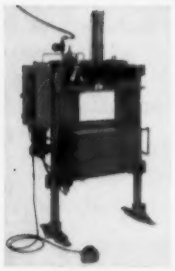
Introduction to Manual Heliarc Welding . . . explains how process works, Films geared primarily to beginner. Color, sound, 16 mm, 8 min, free. *Linde Co.*
Circle No. 412, Page 151-152

Supervising Workers on the Job . . . dramatizes poor results of supervision practices and suggests better methods. Sound, 16 mm, 10 min, rental. *United World Films.*
Circle No. 413, Page 151-152

Shell Molding . . . produced for national television program, film provides introduction to shell molding techniques. Black and white, 16 mm, sound, free. *Cooper Alloy Foundry Co.*
Circle No. 414, Page 151-152



MODEL F VACUUM CHAMBER



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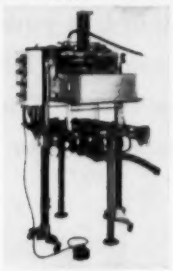

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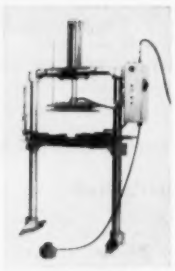

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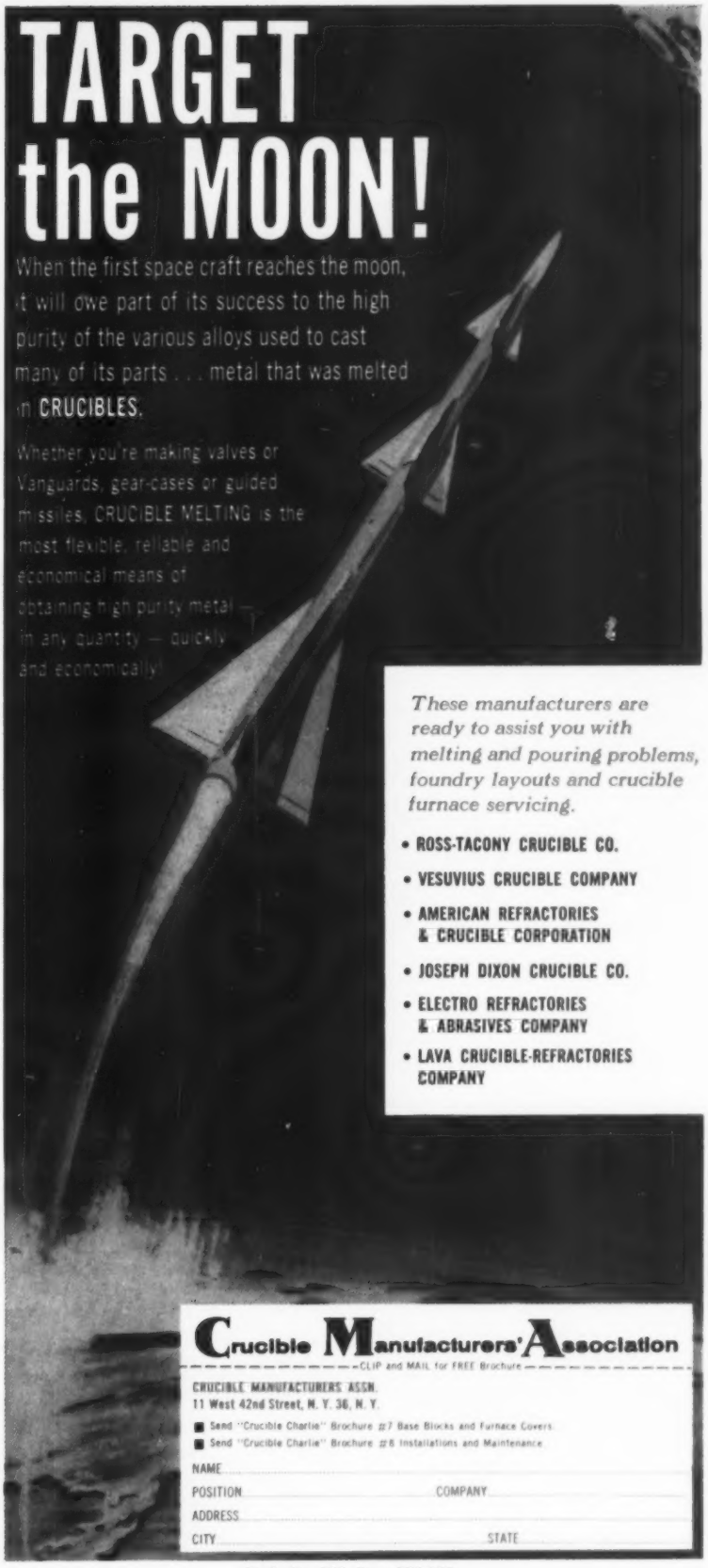
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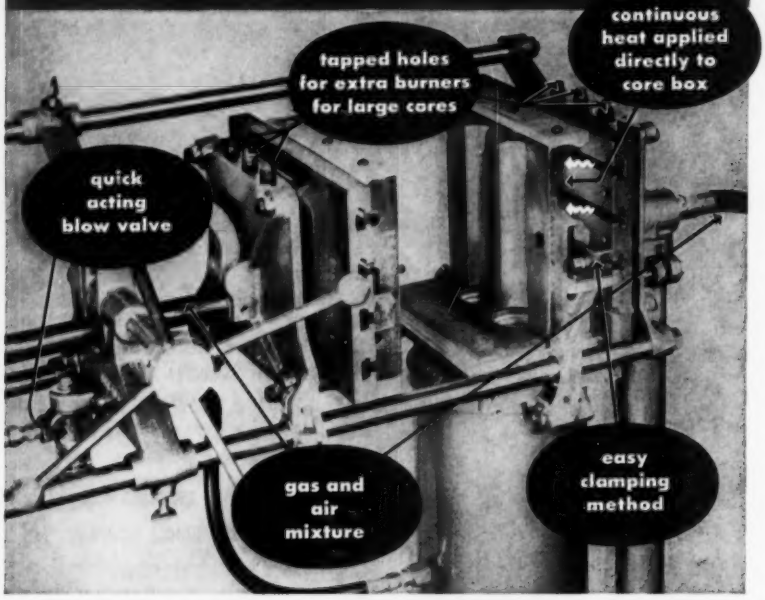
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have you read . . . ?

Business Investment Policy, George Terborgh, Machinery & Allied Products Institute, 260 pp. 1958.

On the premise that big mistakes are costly (such as the wrong investment), the author has made as lucid as possible all the angles of approach to such decisions that have to be made by management. There are formulas. There are charts, statistics and graphs. There are also forms for making analyses of your organization's anticipations. It is a solid attempt to couple hindsight to foresight. This is a study and a manual in the field of finance.

Welding Handbook, American Welding Society. New York, N.Y. (1958) Section II. $9.

This is the Fourth Edition of the Welding Handbook, Gas, Arc & Resistance Welding Processes. The section contains thirteen chapters, each with a bibliography and its own table of contents. The scope of the handbook covers the following subjects: gas welding, pressure gas welding, gas welding and brazing equipment, shielded metal-arc welding, bare metal-arc welding plus impregnated-tape and atomic-hydrogen welding, inert gas metal-arc welding, submerged arc welding, arc welding equipment. Also, spot, seam and projection welding; flash, upset and percussion welding; and resistance welding equipment. Copies may be obtained from the American Welding Society, 33 West 39th St., N. Y. 18.

Metallurgical Progress—3, The Philosophical Library, 88 pp. 1958.

The book is a compilation of articles by specialists in the iron and steel industry; i.e., refractories, non-destructive testing, coke, and foundry technology. These papers were originally reprints from the British journal, "Iron and Steel." The refractory story was written by Dr. Helen Towers, D.Sc., Ph.D., A.R.T.C.

Foundry Practice, William H. Salmon and Eric N. Simons, 381 pp., Pitman, New York. $6.50.

Covers the syllabus of the City and Guilds of London Institute for intermediate students and including specimen examination questions. The title should be prefixed with "steel." The text runs the gamut from blueprint to quality control.

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MODERN CASTINGS
Golf & Wolf Roads
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Please type or print **February/5**

Please have information or bulletins indicated by circled numbers sent to me without obligatio

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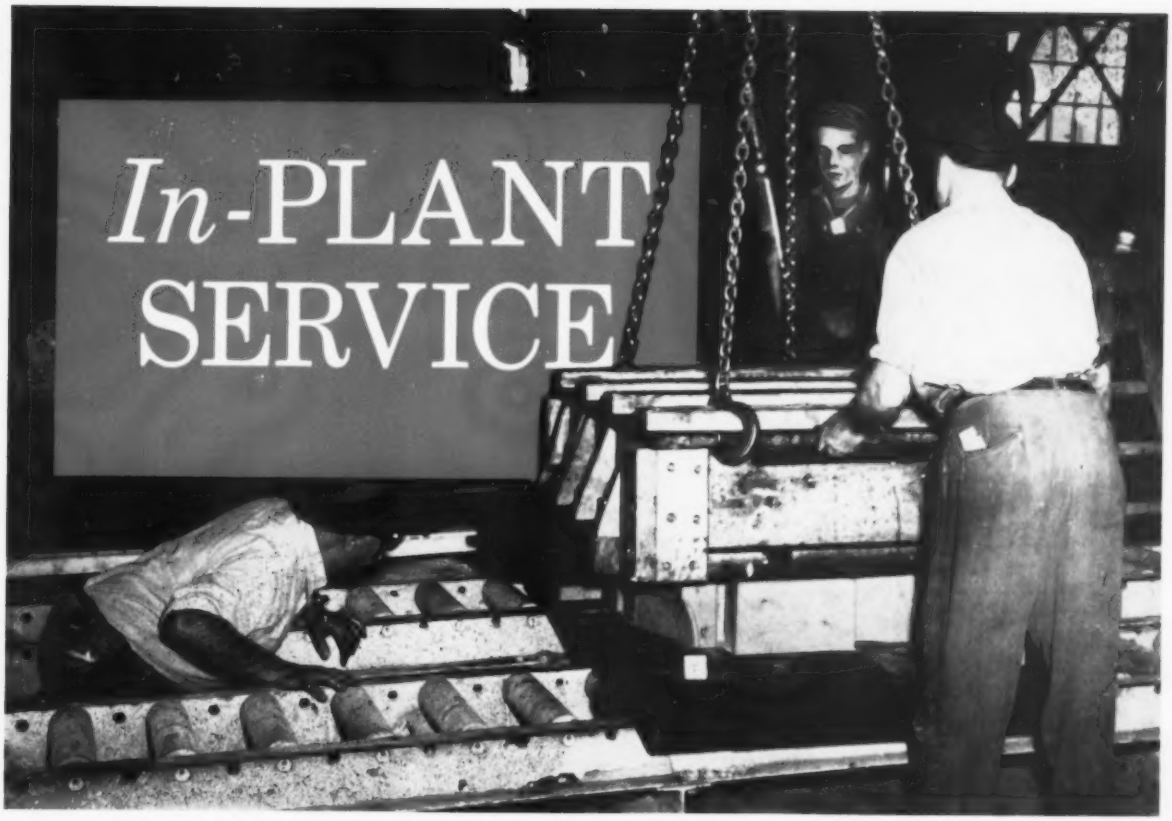
Please use card before August 1, 1959



BASIC REASON

FOR BIG SAVINGS IN 270 FOUNDRIES

KOLD-SETTING Binder will produce optimum results when the installation is engineered by a qualified specialist. That is why we maintain "in-plant" service.

There are now 270 foundries using KOLD-SET to produce better castings at lower costs. The average reported savings is in excess of 40%. Each of these foundries was "started up" with the aid of one of our KOLD-SET engineers. Equipment was studied and evaluated—then, recommendations were made on how KOLD-SET could be adapted to produce best results. The KOLD-SET man stayed with the installation during the early stages and remains on call if further services are required. Periodic service calls further assure our customers of maintaining production.

If you are wondering how KOLD-SETTING Binder will work—a KOLD-SET man will be glad to study your processing and offer recommendations without obligation.

Write or phone!

KOLD-SET®

THE ORIGINAL COLD-SETTING BINDER

G. E. SMITH, INC.

246 Washington Road Pittsburgh 16, Pa.

Warehouse Stocks in Chicago, Boston, Detroit, Philadelphia

Kold-Set is Patented in the United States

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KOLD-SET

ZIRCON WASH

Produces Better Castings because:

1. **Controlled viscosity**
2. **Deep Penetration**
3. **Uniform Film Thickness**

Write for bulletin.

"No machining complaints since I used SMZ alloy"

You can eliminate chilled corners and hard spots in gray iron castings with ladle additions of "SMZ" alloy. Machining rates can thus be improved by as much as 25 per cent, giving you more satisfied customers.

"SMZ" alloy is the most widely used inoculant in the iron foundry industry. As little as 2 to 4 pounds of "SMZ" alloy per ton of iron are sufficient to eliminate chill in light castings. For harder irons of lower carbon and silicon contents, a larger addition of the alloy may be required.

For information on how "SMZ" alloy can improve the machineability of your castings, contact your ELECTROMET representative. Ask for the booklet, "SMZ Alloy – An Inoculant for Cast Iron."

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

These chill blocks show how "SMZ" alloy reduced chill in a 3.15% carbon, 1.80% silicon iron.

Electromet
FERRO-ALLOYS AND METALS

UNION CARBIDE

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